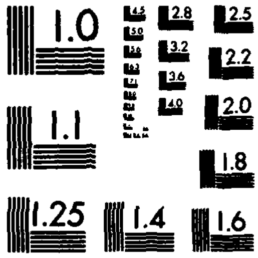

MICROCOPY RESOLUTION TEST CHART
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The purpose of this report is to provide the significant design, construction and operational information which can be used by engineers to (1) familiarize themselves with the project (2) reevaluate the embankment in the event unsatisfactory performance occurs and (3) provide guidance for designing comparable future projects.

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OPERATION AND MAINTENANCE MANUAL

HILLSDALE LAKE
BIG BULL CREEK, KANSAS

APPENDIX V

EMBANKMENT CRITERIA AND
PERFORMANCE REPORT

SEPTEMBER 1984

DEPARTMENT OF THE ARMY
KANSAS CITY DISTRICT, CORPS OF ENGINEERS
KANSAS CITY, MISSOURI

NOTE:

This is a condensed volume of the Hillsdale Embankment Criteria Report. Plates containing record control laboratory test results and instrumentation data have been removed to make the report less voluminous. Summaries of laboratory tests and typical instrumentation data are provided in this volume. The following plates are not included in this volume, but can be obtained upon request from the Kansas City District.

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OPERATION AND MAINTENANCE MANUAL
HILLSDALE LAKE
BIG BULL CREEK, KANSAS

APPENDIX V
EMBANKMENT CRITERIA AND PERFORMANCE REPORT

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218	Air Cell Piezometer P-94-3	0-15-947
219	Air Cell Piezometer P-94-4	0-15-948
220	Air Cell Piezometer P-94-5	0-15-949
221	Open Tube Piezometer P-94-6	0-15-950
222	Open Tube Piezometer P-94-7	0-15-951
223	Open Tube Piezometer P-94-8	0-15-952
224	Open Tube Piezometer P-94-9	0-15-953
225	Open Tube Piezometer P-94-10	0-15-954
226	Open Tube Piezometer P-94-11	0-15-955
227	Open Tube Piezometer P-94-12	0-15-956
228	Open Tube Piezometer P-94-13	0-15-957
229	Open Tube Piezometer P-94-14A	0-15-958
230	Open Tube Piezometer P-94-15	0-15-959
231	Open Tube Piezometer P-94-16	0-15-960
232	Open Tube Piezometer P-94-17	0-15-961
233	Open Tube Piezometer P-94-18	0-15-962
234	Open Tube Piezometer P-94-19	0-15-963
235	Open Tube Piezometer P-94-20	0-15-964
236	Open Tube Piezometer P-95-1	0-15-965
237	Open Tube Piezometer P-99-2	0-15-967
238	Open Tube Piezometer P-101-1	0-15-968
239	Open Tube Piezometer P-101-2	0-15-969
240	Air Cell Piezometer P-104-1A	0-15-970
241	Air Cell Piezometer P-104-2	0-15-971
242	Air Cell Piezometer P-104-3	0-15-972
243	Air Cell Piezometer P-104-4	0-15-973
244	Open Tube Piezometer P-104-5	0-15-974
245	Open Tube Piezometer P-104-6	0-15-975
246	Open Tube Piezometer P-104-7	0-15-976
247	Open Tube Piezometer P-104-8	0-15-977

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Plate No.	Title		File No.
248	Open Tube Piezometer	P-104-9	0-15-978
249	Open Tube Piezometer	P-104-10	0-15-979
250	Open Tube Piezometer	F-104-11	0-15-980
251	Open Tuhe Piezometer	P-104-12	0-15-981
252	Open Tube Piezometer	P-104-13	0-15-982
253	Open Tube Piezometer	P-104-14	0-15-983
254	Open Tube Piezometer	P-105-1	0-15-984
255	Open Tube Piezometer	P-108-2	0-15-986
256	Air Cell Piezometer	P-113-1	0-15-987
257	Open Tube Piezometer	P-113-2	0-15-988
258	Open Tube Piezometer	P-113-3	0-15-989
259	Open Tube Piezometer	P-120-1	0-15-990
260	Open Tube Piezometer	P-120-2	0-15-996
261	Inclinometer	I-72-1	0-15-1044
262	Inclinometer	I-72-2	0-15-1045
263	Inclinometer	I-82-1	0-15-1046
264	Inclinometer	I-82-2	0-15-1047
265	Inclinometer	I-90-1	0-15-1048
266	Inclinometer	1-90-2	0-15-1049
267	Inclinometer	I-91-1	0-15-1050
268	Inclinometer	I-99-2	0-15-1052
269	Inclinometer	I-108-2	0-15-1054
270	Inclinometer	I-113-1	0-15-1055
271	Inclinometer	I-114-1	0-15-1056

OPERATION AND MAINTENANCE MANUAL
HILLSDALE LAKE
BIG BULL CREEK, KANSAS

APPENDIX V

CHAPTER 1

INTRODUCTION

1-01. Purpose and Scope of Report. The purpose of this report is to provide in one volume the significant information needed by engineers to familiarize themselves with Hillsdale Lake, reevaluate the embankment in the event unsatisfactory performance occurs, and provide guidance for designing comparable earth dams. The scope of this report provides a summary record of significant design data, design assumptions, specification requirements, construction equipment, construction procedures, construction experience, field control and record control test data, and embankment performance as monitored by instrumentation during construction and during initial lake filling.

1-02. Project Purpose. The project purposes include flood control, water supply, water quality control, and recreation, including fish and wildlife enhancement. The percentages of benefits assigned to the authorized purpose are 24 percent for flood control, 48 percent for water supply, 20 percent for water quality control and 8 percent for recreation. The average benefits, at 1977 price levels, attributable to the Hillsdale Lake over a 100-year period total $2,962,000.

1-03. Project Authorization. The Hillsdale Lake was authorized as a flood control project by the Flood Control Act of 1954 (Public Law 83-780) which states in part:

> "The comprehensive plan for the Missouri River Basin, approved by the Act of June 28, 1938, and as amended and supplemented, is hereby further modified to include the project for flood protection on the Osage River and tributaries, Missouri and Kansas, substantially in accordance with the recommendations of the Chief of Engineers, in House Document Numbered 549, Eighty-first Congress."

House Document No. 549, 81st Congress states in part:

> "The Osage River Basin plan consists of a nine-reservoir system (Hillsdale included) to be operated as a multiple-purpose project with the primary purpose of flood control. . . . the nine-reservoir system would control a drainage area of 11,500 square miles or 75 percent of the total area of the basin. The system will provide a very high degree of protection from flooding on the Osage River; reduce flood heights on the Missouri and Mississippi Rivers; provide storage for increasing low-water flows for the improvement of water supply, abatement of pollution, and improvement of navigation; and facilities for the production of hydroelectric power."

CHAPTER 2

PROJECT DESCRIPTION

2-01. Project Location. The Hillsdale Dam is located on the Big Bull Creek, Kansas, approximately 2 1/2 miles west of U.S. Highway No. 169 and 5 miles northwest of Paola, Kansas. The dam is located in Miami County with the lake extending north into Johnson County. Location and vicinity maps are shown on plate 1. Major thoroughfares and project access is shown on plate 2. A general plan of the damsite is shown on plate 3.

[illegible]

[illegible]

[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]:	
Line A	[illegible] (underwater)
Line B	25 [illegible]
Line C	26 [illegible]
Line D	19 [illegible]

4. Reservoir

[illegible] Line	Elev. 936.0

Reservoir Storage:

Elevation of [illegible]		Surface area (acres)	Storage Allocation: Initial (inches)	Initial (ac.-ft.)	100-year (inches)	100-year (ac.-ft.)
Flood control	931.0	7,010	10.9	84,000	10.5	81,000
[illegible]	9[illegible].0	[illegible],500	9.9	75,000	8.8	68,000
[illegible]			(1.5)	(11,[illegible])		
Totals			20.8	160,000	19.3	149,000

5. Spillway

Location	Just beyond right abutment
Type	Uncontrolled limited service
Crest Elevation	Elev. [illegible].0
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]

[illegible]

[illegible]	
Location	[illegible] + 60, near left [illegible]
Type	[illegible], 11.67 by 15.[illegible]-foot [illegible] conduit
Capacity at top multipurpose pool:	
One Gate	4,200 c.f.s.
Two Gates	6,150 c.f.s.
Capacity at Spillway Design Flood:	
One Gate	4,920 c.f.s
Two Gates	7,400 c.f.s.
Invert elevation at intake	Elev. 868.0
Invert elevation at outlet	Elev. 865.0
Length of Conduit:	
Portal to Portal	800 feet
Conduit only	690.13 feet
Gates:	
Service	Two 6' 8" by 15'6" hydraulically operated fabricated slide gates
Main Emergency	One 6' by 16'7" fixed wheel cable hoist operated fabricated gate

2-03. Lake Description. Based on the multipurpose pool elevation of 917 feet above mean sea level, Hillsdale Lake has 51 miles of shoreline, a mean depth of 27 feet, a mean breadth of approximately 1 mile, and a length of approximately 6 miles. The major topographic feature of the region is the Bull Creek Valley which is joined from the northeast by the Little Bull Creek Valley. Mature to submature dissection of the plain has resulted in a topography characterized by gently rolling uplands and comparatively broad valleys. Maximum relief in the area is approximately 180 feet. Valley slopes are somewhat steeper along Big Bull Creek than along Little Bull Creek. The steeper slopes and valley walls are mainly brush and timber covered.

2-04. Dam Description. The dam is a zoned, compacted earthfill embankment with a crest length of 11,640 feet which includes a 2,590 foot dike section on the upper right abutment. Crest width of the embankment is 30 feet with the dike section having a crest width of 15 feet. The embankment has a central impervious core across the valley with random and berm zones both upstream and downstream. The impervious core is tied to bedrock with a cutoff trench across the valley. The embankment includes an inclined pervious drain to intercept through seepage. The inclined pervious zone drains to pervious stringers extending to the downstream toe in the valley and to continuous pervious blankets extending to the toe on the abutments. The maximum height above streambed is 100 feet, while the height above flood plain is approximately 75 feet. The elevation of the top of dam is 952.2 which provides 4.2 feet of freeboard above the spillway design flood. The upper right abutment embankment (dike section) is not zoned. It consists of compacted impervious material from the spillway excavation. The lower right abutment embankment includes the Big Bull Creek where closure was made. The various embankment sections include the upper right abutment, lower right abutment, main valley reach, Little Bull Creek area, outlet works, and the left abutment. Details of the various sections are shown in the typical embankment sections on plates 13 and 14. The outlet works is not perpendicular to the dam axis therefore the conduit section and transitions are at different locations upstream and downstream. The outlet works section consists entirely of impervious material with the exception of the pervious backfill surrounding the conduit downstream of the dam axis. The upstream slope protection is designed to provide slope protection at the more frequent pool elevation and on the steep slopes near the embankment crest. Rock protection from the toe extending as high as Elevation 905.2 consists of limestone and shale obtained from required excavation. Riprap and bedding provides protection to Elevation 921.0 with a grass covered 1 on 3 slope transitioning to a 1 on 10 slope between Elevation 921.0 and 942.2. Rock protection consisting of 21 inch riprap provides slope protection from Elevation 942.2 to the crest of the dam.

2-05. Spillway. The spillway is located on the right abutment of the dam. The spillway is a limited service, uncontrolled, flat crested notch type. It is 50 feet wide and level throughout its 4,950 feet of length. It has a crest elevation of 935.0 feet, m.s.l., and 1 on 3 excavated side slopes.

2-06. Outlet Works. The outlet works is located near the toe of the left abutment and consists of an approach channel, intake tower and service bridge, cut-and-cover conduit, stilling basin, and outlet channel. The approach channel is approximately 1,750 feet long with an excavated bottom width of 30 feet and 1 on 2.5 side slopes. The approach channel originates at

the confluence of the Scott Branch and Big Bull Creek and intersects Little Bull Creek prior to connecting with the approach walls and intake structure. A combination wet well-dry well intake tower consists of a combination trash fender and trashrack structure, streamlined inlet, gate passageways, a transition from the gate passageway to the conduit, a multilevel low flow intake within the trashrack structure, two wet wells with a single cable-hoist operated emergency gate, a dry well with two hydraulically operated service gates, an operating floor, a service deck, and an entrance house. Access to the structure is provided by a service bridge from the embankment to the intake structure. The 11.67- by 15.92-foot oblong conduit is located in open-cut excavation and is covered with impervious material, upstream and pervious downstream of the dam axis. The total length of the conduit and intake structure, portal to portal, is approximately 802 feet long. The stilling basin and downstream transition structure provides for energy dissipation by a conventional hydraulic jump to prevent serious erosion of the downstream channel. In cross section, the stilling basin is a U-wall type structure. Baffles and an end sill are built into the stilling basin floor slab. Walkway platforms are provided at the top of the stilling basin walls for observation and fishing. Ramps constructed along the riprap adjacent to the outlet provide fishermen access to the outlet channel.

2-07. Reservoir Operations. Hillsdale Lake is one unit in a system of multiple-purpose projects which comprise a comprehensive plan for flood control and water resource development in the Missouri River basin and its Osage River tributary basin. Flood control storage in Hillsdale Lake acts in conjunction with the other flood storage projects in the Osage River basin to reduce flooding on the Marais des Cygnes, Osage and Lower Missouri River. Hillsdale Lake will have storage for sediment, low-flow supplementation, water supply, and flood control. Sediment storage will provide 11,000 acre-feet of sediment allocation for a 100-year design period. The 68,000 acre-feet multipurpose pool allocation will furnish a water supply withdrawal of 32 cubic feet per second on a 2 percent chance dependability and low flow supplementation of 13 cubic feet per second based on a 10 percent chance. Results of a historical period of record reservoir operation are shown on plate 18, as a Lake Stage Frequency Curve for Hillsdale Lake.

CHAPTER 3

GEOLOGY

3-01. Physiography. Hillsdale Lake is located in the northeastern part of the Osage Plains section of the Central Lowlands physiographic province. This section is characterized by a series of plains separated by eastward facing escarpments formed by differential erosion of Pennsylvanian limestone and shale strata which dip gently westward. Big Bull Creek and Little Bull Creek rise in the southwestern corner of Johnson County near the town of Gardner, Kansas. The two streams merge about 1,000 feet downstream of the dam axis and flow in incised channels with a moderate amount of meandering. At the damsite the flood plain is about 3,000 feet wide. Isolated terrace deposits of Wisconsinan age occur in Big Bull Creek valley upstream and downstream of the dam axis. The valley slopes are mantled primarily with residual soils and some colluvial material (lean and fat clays) ranging in thickness from 0 to 20 feet.

3-02. Description of Overburden. The description of the overburden is based on observations made during the excavation of the cutoff trench.

a. Valley Alluvium. The valley alluvium consists of up to 30 feet of Pleistocene and recent deposits of lean and fat clays with clayey sand several feet thick at the base. Valley alluvium across the valley, except where the Drum limestone was eroded away in the Big Bull Creek channel (Station 80+10 to 82+30. Lean and fat clay deposits vary from 25 to 30 feet thick. The Pleistocene and recent deposits contain very few sand and gravel deposits. A 3-foot thick sand and gravel deposit with a minor amount of water exists between Station 80+00 and 82+20 on the upstream side of the trench. A small deposit of sand and gravel one foot thick exists between Stations 104+00 and 105+00. These sand and gravel deposits correspond to the creek crossings.

b. Upland Overburden. On the right abutment, overburden ranges in thickness from 6 to 20 feet and consists largely of residual fat clay derived from weathering of the Lane shale formation. The maximum thickness occurs from Station 36+00 to Station 46+00. From Station 44+00 to Station 75+00 the Lane shale is absent and residual clays are resting directly on weathered Iola limestone. From Station 75+00 to Station 79+00 fat and lean clays are resting on the Chanute shale. Bedrock between Station 75+00 to Station 78+50 is a moderately hard, friable, very fine grained, thin bedded, tan, sandstone. The steep slope from Station 78+00 down to Big Bull Creek at Station 79+00 is thinly mantled. There is less than 6 feet of fat clay and many large sandstone slabs from the overlying Chanute shale. On the left abutment overburden is comparatively thin. From Station 105+00 to Station 112+00 the overburden ranges from 6 to 12 feet thick over the Chanute shale. From Station 112+00 to Station 116+00 the overburden was on the Iola limestone. From Station 116+00 to Station 124+00 the overburden is on the Lane shale. From Station 112+00 to Station 124+00 the overburden is composed of lean and fat clays. Limestone fragments were not common and no sand was noted from Station 105+00 to Station 124+00.

3-03. Bedrock Stratigraphy. Bedrock units present at the damsite are of the Pennsylvanian System, Lansing, and Kansas City groups. They consist of alternating beds of limestone and shale with occasional zones of sandstone and siltstone. Unexposed similar sedimentary strata extend about 2,000 feet to the Precambrian basement. The bedrock units are described, in descending order, in the following paragraphs:

a. Lansing Group.

(1) Plattsburg Formation. These units were not encountered in the excavations.

(a) Spring Hill limestone is 14 feet thick, moderately hard, dense to finely crystalline with occasional pits. It is light gray and massive to thin bedded with shaly partings.

(b) Hickory Creek shale is 0.5 foot thick, soft, platy, calcareous and dark gray.

(c) Merriam limestone is 2.5 feet thick, moderately hard, dense to finely crystalline, oolitic, thin bedded, fossiliferous and light gray.

(d) Bonner Springs shale is 19 feet thick, soft to very soft and platy with calcareous partings. It is light to dark gray with a maroon zone near the center. A moderately hard, very fine grained sandstone occurs at the base.

(2) Wyandotte Formation.

(a) Farley limestone, Island Creek shale (0.1 foot thick) and Argentine limestone members total about 14 feet thick. They are moderately hard, dense, thin-bedded, with wavy shale partings and light gray to buff with light blue mottling. These units were not encountered in the excavations.

(b) Lane shale member is about 100 feet thick, soft to occasionally very soft, clayey to sandy, platy, gray to dark gray with occasional carbonaceous partings and limestone nodules. The upper half includes sandstone, moderately hard, fine grained, micaceous, occasionally calcareous, thin bedded and gray.

(3) Iola Formation.

(a) Raytown limestone member is about 17 feet thick, moderately hard, dense to finely crystalline, argillaceous, fossiliferous, thin to medium, wavy bedded and light bluish gray. The ledge contains two thin shale beds.

(b) Muncie Creek shale member is 0.5 feet thick, soft, clayey, calcareous, gray with occasional phosphate modules.

(c) Paola limestone member is 2.5 feet thick, moderately hard, dense, fossiliferous, thick bedded and light gray.

(4) Chanute Formation.

(a) Chanute shale is approximately 30 feet thick, soft to moderately hard, clayey to silty, platy to massive, dark gray to green with pinkish limestone nodules. Sandstone and siltstone beds are common in the upper part. A soft shale underclay with numerous slickensides occurs beneath a thin coal seam near the middle. The sandstone and siltstone are moderately hard, very fine grained, calcareous, thin bedded and gray to brown. The siltstone is often interlaminated with shale.

(b) In the outlet works excavation several zones within the Chanute shale formation have been recognized. They are described in descending order, below.

Zone A is about 5 feet thick. It is shale, soft, platy to fissile and dark gray with occasional moderately hard siltstone beds.

Zone B is about 8 feet thick. It consists of siltstone and sandstone, moderately hard, thin bedded to laminated, calcareous, light and dark gray with a 3/4 inch thick coal seam at the base.

Zone C is about 5.5 feet thick. It is shale, soft, blocky and dark gray with numerous slickensides.

Zone D is about 1.8 feet thick. It is soft, blocky, purple shale with numerous slickensides.

Zone E is about 5 feet thick. It is siltstone, moderately hard, thin to medium bedded, calcareous and greenish gray with limestone lenses and nodules.

Zone F is about 3.5 feet thick. It is shale, soft, laminated and gray. It contains numerous tight vertical joints.

(5) Drum Formation. Cement City limestone member is 4 feet thick, moderately hard, dense to finely crystalline, thin to medium bedded, fossiliferous, light gray with thin green wavy shale partings.

(6) Cherryvale Formation. The Quivira shale member is the only unit encountered in the excavations.

(a) Quivira shale member is 12 feet thick, soft, clayey to silty and dark gray. It contains siltstone and underclay and occasional very soft partings and bands. A thin coal seam commonly occurs in the upper 4 feet. The lower portion is often interlaminated with moderately hard, light gray siltstone.

(b) Westerville limestone member is 2.5 feet thick, moderately hard, thin-bedded, argillaceous, brownish gray with green shaly partings and zones of nodular limestone in a matrix of green shale.

(c) Wea shale member is 21 feet thick, soft to moderately hard, clayey to silty, platy, occasionally calcareous and contains siltstone bands and partings. It is dark gray to green gray.

(d) Block limetone member is 14 feet thick, moderately hard, dence to very finely crystalline, thin wavy bedded, light brownish gray with occasional light blue mottling and numerous dark gray, soft shale partings.

(e) Fontana shale member is 14 feet thick, soft to moderately hard, clayey to silty, platy, dark gray to green gray with occasional limetone partings.

(f) Winterset limetone member is 20 feet thick, moderately hard to hard, finely crystalline, argillaceous, cherty, thick bedded, and light gray.

3-04. Bedrock Structure. The damsite is located on the Prairie Plains homocline. The term is applied to strata that dip in one direction at a uniform angle. The regional dip is 20 to 30 feet per mile to the northwest. The regional dip, however, is not apparent at the damsite; instead, the local strata dip slightly to the northeast at a rate of about 15 feet per mile. The rock units are at a lower elevation on the left abutment than on the right.

3-05. Bedrock Weathering. From Station 45+00 to Station 58+00 the Raytown limestone in the cutoff trench was weathered with open joints and clay pockets. The upper six to eight feet of the ledge was excavated down to a shale parting near Elevation 910. From Station 69+00 to Station 72+00 the Chanute shale was soft and weathered. The upper five feet were excavated to expose a firm unweathered shale surface. From Station 75+00 to Station 78+50, up to five feet of weathered Chanute shale was excavated. From Station 79+50 to Station 106+30 a five foot thick ledge of weathered Drum limestone and three feet of the underlying Quivira shale were excavated. From Station 106+30 to Station 114+15, the upper five feet of weathered Chanute shale was excavated. A clay filled joint in the Raytown limestone was encountered on the downstream wall of the cutoff trench at Station 114+34. From Station 114+15 to Station 118+50 Raytown limestone forms the floor of the trench. From Station 118+50 to Station 121+00 the upper two feet of weathered Lane shale was excavated.

3-06. Leaching and/or Solution Activity. Several solution cavities were encountered in the Paola limestone and Chanute shale on the walls of the outlet works excavation.

3-07. Jointing. Joints in the Raytown and Drum limestones on the floor of the cutoff trench were tight and indistinct in the abutments and joints in the Drum were open in the valley. The major joints strike north 45 degrees to 65 degrees east. The minor joints strike north 30 degrees west. The joints were cleaned and filled with grout. During foundation grouting they tested tight. A few joints were noted in the Raytown limestone on the floor of the cutoff trench. A few joints were noted in the Drum limestone on the floor of the cutoff trench from Station 79+00 to Station 79+50. They were also tight. Numerous joints were found in the Chanute shale in the stilling basin foundation. The joints were vertical and open for a depth of about 7 inches. One set strikes south 80 degrees east and the other set strikes north 25 degrees east.

3-08. Ground Water. Overburden and bedrock units at the damsite and in the reservoir were expected to be poor aquifers. The excavations through the

fat clays of the cutoff trench disclosed only two clayey, gravelly, sand areas in the old channels of Big and Little Bull Creeks. Except for the initial discharge when first disturbed, groundwater seepage was insignificant. Groundwater seepage in the outlet works excavation was also minimal. Pressure testing indicated the underlying shales and limestone were relatively impervious. Small yields had been reported in the Chanute shale in wells outside the reservoir. Excavation of the Iola and Drum limestones confirmed that they were poor and aquifers. Jointing was well defined and slightly open only in the outcrop areas. Grouting confirmed the limestones and shales were tight except for one small area in the Chanute shale that accepted most of the grout injected. This area was a sandstone lense near the top of the Chanute shale. Occasional open joints in this sandstone probably supply what little well water is available in the area.

CHAPTER 4

HISTORY OF PROJECT DESIGN

4-01. Investigations Prior to Project Authorization. Studies prior to project authorization consist of reports prepared by the Corps of Engineers, reports of other agencies, flood damage investigations, special field investigations, and the report on the Osage River and Tributaries (Missouri and Kansas), House Document No. 91, Seventy-third Congress and other information used in the preparation of House Document No. 549, Eighty-first Congress, which is the project document.

4-02. Investigations Subsequent to Authorization. Post authorization studies included topographic surveys, subsurface explorations, and preliminary contacts with governmental agencies and local groups having an interest in the project. Design studies leading to the following DMs were initiated.

TABLE 1

Hillsdale Design Memorandums

DM Number	Title
1	Project Economics
2	Hydrology
3	General
3	Appendix E - Recreation Resources
4	Preliminary Cost Allocation
5	Source of Construction Materials
6	Administrative Facilities
6	Supp 1, Administrative Facilities
7	Soil Data & Embankment Design
7	Supp A, Soil Data & Embankment Design
8	Outlet Works and Spillway
9	Miami County Road Relocations
10	Access Roads
11	Real Estate
11	Supp A, Miami Co. Rd. Relocations
12	Relocation of Power and Telephone Lines
13	Master Plan
14	Petroleum & Pipeline Relocations
15	Interpretive Prospectus and Exhibit Design Concept
16	Lake Clearing
17	O&M Water Supply
18	Initial Reservoir Filling Plan

Preliminary embankment design quantities were evaluated for several sites to be considered in the site selection procedure. A site selection conference was held in February of 1969 with a summary of the data presented being published in a report. Geologic investigating and soil testing to determine strength characteristics and moisture-density relationships of proposed borrow material as well as the stress-strain and consolidation characteristics and

strength parameters of the foundation materials proceeded while the General Design Memorandum was being prepared. The additional foundation information resulted in a revised embankment. Details of the modified design are presented in Design Memorandum No. 7, Soil Data and Embankment Design, March 1971. In response to review comments to DM 7 a Supplement presenting the results of additional exploration and testing of the foundation shales was prepared in December 1971. The outlet works embankment design and the conduit location were revised in the supplement. Stage construction was planned to allow observation and analysis of the foundation conditions during excavation of the cutoff trench. Advance plans and specifications for Stage I were submitted October 1974. Advance plans and specifications for Stage II were submitted February 1976. Based on results of additional testing of the Quivira shale and evaluation of the foundation conditions during Stage I construction, a revised embankment design was presented in January 1978 in Design Memorandum No. 7, Supplement A, Soil Data and Embankment Design. Stage III plans and specifications were submitted April 1978.

4-03. Changes in Project Plan. The following changes have been made to the project as planned in the General Design Memorandum.

a. Top of Dam. The top of dam has been changed from Elevation 953.0 feet, m.s.l. to Elevation 952.2 feet, m.s.l. This change was the result of modifying the practice of rounding up the top of dam elevation to an even foot.

b. Conduit. A 13.5 foot diameter single horseshoe conduit was recommended in the General Design Memorandum, but conduit studies and comments on similar projects indicated that an oblong conduit be used.

c. Intake Tower. Changes in the intake tower design to conform with the oblong conduit and other modifications are presented in Design Memorandum No. 8, Outlet Works and Spillway.

d. Stilling basin. Hydraulic stilling basin model studies for Fort Scott and Clinton Lakes were recently conducted at Waterways Experiment Station (WES). Based on these studies, the Hillsdale stilling basin has been modified to include the results of these studies.

e. Spillway control sill. The spillway control sill has been deleted.

f. Project name. In accordance with EC 1130-2-75, dated 10 August 1970, the name "Hillsdale Reservoir" is changed to "Hillsdale Lake."

g. Embankment. Investigations subsequent to the GDM revealed the Quivira shale underclay with a lower shear strength than assumed. This resulted in an embankment design with flatter slopes to provide stability. This redesign resulted in the embankment presented in DM No. 7, which proposed construction of the embankment, outlet works, spillway and toe roads in one contract. Limited test data on the Chanute shale underclay resulted in additional drilling and testing after submission of DM No. 7. The test results indicated a lower residual strength. The revised strength required the 1 on 6 slope in the conduit section to be changed to 1 on 8. The revised embankment required moving the tower upstream, however, borings indicated the

adequacy of the bedrock would become marginal. This required a change in the conduit location. The location was changed from being perpendicular to the dam axis at Station 113+10 to being skewed 9 degrees from perpendicular at Station 113+60. The proposed one contract construction of the embankment was changed to stage construction to allow an evaluation of the foundation conditions and any required changes in the embankment design to be accomplished prior to the embankment construction. Changes in design prior to construction include the following.

(1) Embankment section. The upstream and downstream embankment toes were adjusted inward to provide a 1.4 safety factor for the partial pool and steady seepage cases. The reduced safety factor was believed to be appropriate based on the conclusion the Quivira underclay was not continuous or extensive. The resulting revised embankment sections are shown on plates 65, 66 and 67. The change in location of the toes varies from 90 feet to 140 feet.

(2) Pervious. A change in the pervious was made on the basis of economy. A significant cost savings was made by using 50 foot wide pervious stringers in the valley section in lieu of the continuous blanket. The inclined pervious slope was also changed to 1 on 1 instead of 1 on 0.5 to conserve pervious.

(3) Riprap. An evaluation of the riprap design determined that the necessity for carrying riprap above Elevation 921.0 was marginal. Using stockpiled rock from required excavation in the lower portions of the embankment instead of riprap provided a significant savings. Riprap would also be placed on the top 10 feet of the embankment. The revised slope protection is shown on plate 16.

(4) Grout curtain. A change in the design of the grout curtain as shown in the embankment DM was made during the preparation of the Stage I plans and specifications. The grout curtain across the valley floor (Station 79+50 through Station 106+50) was eliminated. Exploratory borings and pressure testing indicated the bedrock strata are sufficiently impermeable, and that a grout curtain is not required to prevent adverse seepage through bedrock underlying the valley cutoff trench.

(5) Clay blanket. An upstream 3 foot thick (CH) clay blanket was constructed to Range 1000 upstream on the right abutment. The blanket prevents seepage through an exposed (see plates 4 and 5) geologic section from the Raytown limestone to the Drum limestone. The blanket did not withstand the wave action and surface runoff, and repair and protection was required before initial filling. The blanketed area was protected by placing filter fabric over the blanket followed by 15-inch riprap over the fabric. Protection does not extend below Elevation 898.

CHAPTER 5

FOUNDATION AND EMBANKMENT DESIGN

5-01. Foundation Investigations.

a. Investigations Prior to Construction. Geological investigations of the damsite included field reconnaissance, review of geologic literature, analysis of air photos, survey of water wells, review of gas and oil well log-sand exploratory drilling. Two hundred and ninety borings were made at the damsite. Fifty-five were bedrock core borings, thirteen were combination undisturbed and core borings, and forty-four were drive borings. Sixty-four drive or auger borings were made in the borrow areas. Twenty-seven bedrock borings were hydraulically pressure tested. Nearly all the borings tested tight but one boring, C-81 accepted 16.7 gpm in the weathered upper two feet of the Chanute shale. Bedrock cores were 1-7/8, 2-1/8 and 6-inch diameter and overburden borings ranged from 3 to 6-inch diameter. Nineteen piezometers were installed in the flood plain to obtain information on water level fluctuations.

b. Investigations During Construction. During excavation of the cutoff trench, the contractor drilled several air tract holes into exposed bedrock on both abutments to determine depth and extent of joints and weathering in the Raytown limestone. Several exploratory NX core holes were drilled horizontally into the sloping faces of the Raytown limestone. They were pressure tested and grouted during Stage I and Stage II construction. Government drill crews drilled 135 drive holes, 12 auger holes, 9 NX core holes, one combination drive and core hole and 10 test pits.

5-02. Embankment Foundation.

a. Right Abutment (Station 6+00 to Station 79+00). --The right abutment extends almost 1.4 miles across a gentle slope. Overburden thickness ranges from 5 to 25 feet, consisting primarily of residual fat clay with a lesser amount of lean clay and minor amounts of sandy and silty clays. Water contents range from 14 to 31 percent. Liquid limits as high as the low seventies are common. Bedrock units immediately underlying the overburden are as follows by approximate stationing: Lane shale from Station 6+00 to 42+00, Raytown limestone from Station 42+00 to 63+00, Paola limestone from sta. 63+00 to 74+00, and the Chanute Shale from Station 74+00 to 79+00. The thin Muncie Creek Shale, less than 0.5 feet thick, lies stratigraphically between the Raytown and Paola limestones and contacts the overburden for an insignificant horizontal distance at Station 63+00. Overburden-shale contacts are in general, transitional. Weathering in the form of staining extends as much as 10 feet into shales and sandstone but depth to firm rock is generally within 5 feet of the shale surfaces and slightly less in sandstone. In limestone, weathering in the form of partially clay-filled and open bedding planes and joints extends to a depth of 7 feet and occasionally deeper. Where the limestones are extremely weathered, cobbles, boulders, pinnacles and "float" rock have developed to a thickness of 3 to 4 feet. Raytown and Paola limestones and a sandstone phase of the Chanute Shale crop out along the Big Bull Creek valley wall just upstream of the damsite, with the Drum limestone appearing farther upstream. These bedrock strata, except the Drum limestone,

are also exposed along Scott Branch as it flows roughly parallel to the dam axis 1,000 to 2,000 feet upstream. The location and elevation of these outcrops, all below flood pool elevation, dictate the grout curtain limits in the right abutment.

b. Valley (Station 79+00 to Station 106+00). --The valley overburden consists of alluvium from 22 to 30 feet thick. Lean and fat clays predominate, although up to 3 feet of clayey gravelly sand commonly overlies the bedrock surface. Water contents of the clay generally range in the twenties and low thirties, while the water content of the basal gravelly sand material range from 15 to 45 percent. Liquid limits of the fat clay range up to 63. Borings and cutoff trench excavation indicate that the bedrock surface underlying the valley alluvium is comparatively level with a gentle increase in apparent dip toward the left abutment. With one exception, (UC-51) bedrock borings encountered weathered Drum limestone underlying the alluvium in the valley embankment area. At boring UC-51, located about 250 feet upstream of sta. 80+00, the Quivira Shale forms the bedrock surface. Weathering in much of the Drum limestone has opened closely spaced (0.2 foot) wavy shale partings and vertical joints in the valley while the bedrock joints in the abutments remain tight and indistinct. In some instances the weathering has extended through the 4 ± foot thick Drum limestone into the top of the Quivira Shale. A thin coal seam or very carbonaceous shale (0.5 ± foot thick) with associated shale underclay occurs within the upper 4 feet of the Quivira shale. This soft shale underclay has occasional very soft partings and bands. Direct shear (S) tests indicate that the soft shale is weak. It is concluded that the "weak" zone is probably not continuous or extensive based on detailed evaluation during the excavation of the cutoff trench.

c. Left Abutment (Station 106+00 to Station 121+40). --Overburden in the left abutment is residual soil except for the alluvium in the lower portion adjacent to Little Bull Creek. Thickness of the overburden ranges from 7 to 28 feet and consists primarily of lean and fat clays. Two to 3 feet of clayey sand commonly occurs directly overlying the bedrock surface when this surface is the Chanute shale. Water contents of the overburden range from 19 to 41 percent. Liquid limits of the overburden are generally below 60. Bedrock units immediately underlying the overburden are as follows along with approximate stationing: Chanute shale from sta. 106+00 to 111+70, Paola limestone from Station 111+70 to 112+20, Raytown limestone from Station 112+20 to 116+00, and the Lane shale from Station 116+00 to 121+40. The thin Muncie Creek shale, less than 0.5 foot thick, will contact the overburden for an insignificant horizontal distance at approximate Station 112+20. Weathering in limestone, shales and sandstones is as described for the right abutment in paragraph 5-02.a.

5-03. Laboratory Tests. Samples taken from the foundation and the borrow areas were tested in the laboratory to establish soil parameters necessary for the design of the embankment. In general, disturbed samples obtained from the borrow areas were used for remolded testing and samples taken from the foundation were used for undisturbed testing. Identification and classification tests were run routinely on jar samples from both areas. During construction, record control samples were tested to determine the actual characteristics of the in-place fill. The laboratory tests were performed in general accordance with EM 1110-2-1906, "Laboratory Soils Testing."

a. Remolded Tests. Based on the results of the classification tests on jar samples, composites were made from sacks of similar material. Remolded, direct shear "S", and triaxial unconsolidated-undrained, "Q", and consolidated-undrained, "R", tests were performed on these composites. Standard compactions were conducted prior to the strength tests to obtain the moisture content versus dry density relationships. The results from these compaction tests are presented on Plate 46. The test specimens were reconstituted by kneading compaction to dry densities of 95 percent of maximum and at moisture contents ranging from 2.8 percent below optimum to 4.8 percent above optimum. Specimens were tested immediately so as not to allow a thixotropic strength gain.

(1) Remolded Triaxial Compression Tests. The remolded triaxial test specimens were constructed by kneading eight lifts of soil into a split mold and scarifying between each lift. Nominal specimen dimensions were 1.4 inch diameter by 3 inch height. Both "Q" and "R" tests were performed at confining pressures ranging from 0.5 to 4.0 t.s.f. The points on the Mohr circles used to define the strength envelopes were the stresses on a 60 degree plane at failure. Failure was assumed to occur at 15 percent strain if the deviator stress had not peaked beforehand. A summary of the remolded triaxial "Q" and "R" tests is presented on Plate 47.

(2) Remolded Direct Shear "S" Tests. The direct shear specimens were made by kneading the material into a 3.0 or 3.5 inch square box to a thickness of 0.5 inch. A summary of test results used in Design Memorandum No. 7 is presented on Plate 46. During construction, additional remolded direct shear tests were performed on borrow area material. The results of these additional tests supported the original strength envelope. The compaction tests that accompany these additional shear tests are shown on Plate 77, and the actual shear test results are on Plates 78 and 79.

b. Undisturbed Tests. Undisturbed samples (discussed in paragraph 5-01.a.) from both the foundation overburden and the bedrock were tested in the laboratory. All test specimens were hand trimmed in a humidity controlled room to minimize disturbance and moisture loss.

(1) Foundation Overburden. The foundation overburden samples were used for consolidation, direct shear, and triaxial "Q" and "R" tests.

(a) Triaxial tests. Triaxial test specimens were generally tested in sets of 3, each at a different confining pressure. They were trimmed so that all three specimens were from the same layer. Specimen dimensions were 1.4 inch diameter by 3-inch height. The points on the Mohr Circle with normal stresses of $\frac{\sigma_1+\sigma_3}{2}$ and shearing stresses of $\frac{\sigma_1-\sigma_3}{2}$ were used to define the strength envelope. Summaries of foundation overburden strengths are presented on Plates 50 and 51.

(b) Direct Shear "S" Tests. The direct shear test specimens were trimmed into 3.5 inch square shear boxes to a height of 0.5 inch. Some of the tests were performed on a direct shear machine capable of shearing the specimen, then reversing the direction of shear 180 degrees, and shearing the

specimen again without releasing the normal load in the process. In order to obtain the strength at large strain, this procedure was repeated with no reduction in shear strength occurred from additional shearing. A summary of foundation overburden "S" strengths is presented on Plate 49.

(2) Foundation Shales. Only "S" strengths were used for shales in the design. Both the Chanute shale and the Quivira shale were tested for shear strength along the bedding planes and across the bedding planes. The results of these shear tests performed for Design Memorandum No. 7 are presented on Plate 57. It was felt that additional testing was required to support the design strengths used for the shale underclays, so additional direct shear and "R" tests were performed and presented in two supplements to Design Memorandum No. 7. The summary of test results from the first supplement is shown on Plate 57. and the summary from the second supplement (Supplement A) is shown on Plate 58. Although these additional tests resulted in decreasing the residual strength for the Chanute shale, they indicated peak strengths for the Quivira shale to be significantly higher than those used in Design Memorandum No. 7. For design calculations the original "S" strength was used even though the additional tests showed it to be very conservative. For stability analyses performed for this report, it was believed that a revised strength envelope drawn such that one-third of the test results were below it and two-thirds were above it was more appropriate.

c. Record Control Tests. Record control samples taken during construction were used for determining the in place shear strength of the fill. Triaxial "Q", "R", and "R" and direct shear tests were performed on these samples.

(1) Triaxial "Q" Tests. The "Q" test specimens were trimmed from record control samples in pairs; one was tested at a confining pressure of 3.0 t.s.f. and the other at 6.0 t.s.f. Although the specimens were not 100 percent saturated, the strength envelopes were chosen with $\tan \phi = 0$. For the saturated condition, the point on the Mohr circle corresponding to the stresses on the failure plane coincides with the point of intersection with a line drawn tangent to the circles. This is the point that was used in defining the strength envelope. It has a normal stress value of $\frac{\sigma_1 + \sigma_3}{2}$ and a shearing stress value of $\frac{\sigma_1 - \sigma_3}{2}$. A summary of record control "Q" test results is shown on Plates 80 and 81. and the indvidual test results are shown on Plates 88 through 103.

(2) Triaxial "R" Tests. The record control "R" test specimens were generally tested in pairs with one consolidated at 3.0 t.s.f and the other at 6.0 t.s.f. The Design Memorandum No. 7 constructed the strength envelope through the points corresponding to a normal stress of $\frac{\sigma_1 + \sigma_3}{2}$ and a shearing stress of $\frac{\sigma_1 - \sigma_3}{2}$ for undisturbed "R" tests. A summary of record control "R" test results prepared in this manner is presented on Plates 82 and 83. This method of constructing the envelope appears to be inconsistent with the way it is used for slope stability calculations. It is felt that a more appropriate method is to plot the point of shear strength at failure on the plane of failure, against the effective normal consolidation stress on the failure plane. A summary of test results prepared in this manner is shown on Plates 84 and 85, and the individual tests are presented on Plates 104 through 119.

(3) Triaxial "$\bar{R}$" and Direct Shear Tests. Four "$\bar{R}$" tests were run on record control samples. These $\bar{R}$ tests yielded nearly the same results as a drained direct shear test by considering the effective stresses on a 60 degrees failure plane. A summary of "S" strengths from both drained direct shear and triaxial "$\bar{R}$" is shown on Plates 86 and 87, and the individual "$\bar{R}$" and direct shear tests are shown on Plates 120 through 136.

e. Identification of Dispersive Clays. After construction, two areas of the spillway were sampled because they exhibited dispersive behavior. Three types of tests commonly used to identify dispersive clays were performed on these samples. The tests included the lab dispersion, pinhole erosion, and chemical pore water analysis (% Na.). These tests indicated that one area was dispersive while the other was not. The test results are presented on Plates 151A and 151B.

5-04. Embankment. For purpose of embankment design, the dam was divided into six reaches because of the various foundation conditions that exist across the valley. Embankment sections are shown on Plates 13 and 14.

a. Upper Right Abutment (Station 6+10 to Station 60+00). The height of the embankment in this reach varies from 0 to 21 feet. The relatively flat 1 on 6 slopes were designed for aesthetic reasons rather than slope stability. The embankment with seeded slopes requires little maintenance and blends in with the natural surroundings. This portion of the embankment is not zoned, it is constructed of compacted clay and shale from the spillway excavation. Water will be against the upstream slope only at very infrequent intervals (once in excess of 50 years), and then only for a few days at a time. The embankment with seeded slopes requires little maintenance and blends in with the natural surroundings. An inspection trench extends from Station 6+10 to Station 43+75 under the embankment. A cutoff trench to the lower shale seam of the Raytown limestone exists from Station 43+75 to Station 56+55.5. The Raytown limestone on the downstream side of the cutoff trench was covered with a filter material and a pervious blanket. The 1 on 6 slopes transition to 1 on 4 slopes from Station 56+00 to Station 60+00. Downstream pervious blanket begins at Station 59+00 with the pervious extending all the way to the toe between Station 59+00 and Station 60+00. Riprap slope protection on the upstream slope starts at Station 56+00.

b. Lower Right Abutment (Station 60+00 to Station 81+00). The height of the embankment varies from 21 feet to 100 feet in this reach. It includes the Big Bull Creek channel where closure was made. The embankment transitions from Station 60+00 to Station 64+00 where the upstream slope is 1 on 3 from the top of dam to Elevation 928.2 and 1 on 10 to the ground surface. The downstream slope is 1 on 3 from top of dam to elevation 925.8 and 1 on 12 to the ground surface. From Station 73+00 to Station 81+00 the upstream 1 on 10 slope extends to Elevation 900.2 and continues on a 1 on 4 slope to the ground surface. The downstream 1 on 12 slope extends to elevation 900.7 and continues on a 1 on 4 to the ground surface from Station 73+00 to Station 87+00. The primary design consideration in this reach was the Quivira shale underclay. The absence of Drum limestone over a portion of this reach

reduced slope stability and required a larger section than elsewhere. Design of this section was based on the conclusion that the "weak" zone in the Quivira shale underclay was not continuous. This section was designed to provide a factor of safety of 1.4 for the steady seepage and partial pool slope stability cases.

c. Main Valley (Station 81+00 to Station 96+30). The height of the embankment in this reach is approximately 75 feet. This reach contains the Stage I embankment (See Plate 6 for limits of Stage I embankment) constructed from cutoff trench and outlet works excavation. The Stage I embankment was constructed prior to the completion of design of the rest of the embankment. The upstream slope is 1 on 3 from top of dam to Elevation 928.2, a 1 on 10 to Elevation 916.2, a 20 foot flat section at Elevation 916.2 from range 2+07 to range 2+27, 1 on 10 to Elevation 892.2, and 1 on 4 to the ground surface. The flat section was the result of inadvertently specifying that the Stage I embankment be constructed to the grade line of the top of the riprap rather than the bottom of the riprap. The Stage I embankment was overbuilt by two feet, the thickness of the slope protection, requiring a 20 foot flat section in the 1 on 10 slope. The downstream slope is 1 on 3 from top of dam to Elevation 925.8, 1 on 12 to Elevation 905.7, and 1 on 4 to the ground surface. The Quivira shale which was underclay was the primary design consideration in this reach. The Stage I embankment was designed assuming there was a low strength zone in the Quivira Shale continuous across the valley. The conclusion that this was not the case was made after the Stage I embankment was constructed. Therefore, the upstream toe of this reach extends further upstream than the redesigned sections where the toes were adjusted inward.

d. Little Bull Area (Station 96+30 to Station 111+70). The height of the embankment in this reach is approximately 75 feet. The upstream slope is 1 on 3 from top of dam to Elevation 928.2, 1 on 10 to Elevation 905.2, and 1 on 4 to the ground surface. The downstream slope is 1 on 3 to Elevation 925.8, 1 on 12 to Elevation 905.7, and 1 on 4 to ground surface. The foundation overburden "Q" and "R" strengths are lower in this reach than in the main valley. Also a zone of fat clay with a slightly lower "S" strength, which is present in the main valley, is not present in the Little Bull area. The differences proved to be of little consequence in the design of the section. The lower "Q" strengths resulted in a construction halt at Elevation 927.

e. Conduit Section (Station 111+70 to 115+70). The conduit, stilling basin, and intake structure are founded on Chanute shale. The upstream slope is 1 on 3 from top of dam to Elevation 928.2, 1 on 8 to Elevation 898.2, and 1 on 4 to the ground surface. The downstream slope is 1 on 3 from top of dam to elevation 925.8, 1 on 8 to the service road, 1 on 3 to Elevation 881, and 1 on 2 to the ground surface. The steeper embankment sections in the conduit are possible because an all impervious and pervious section is used and the Quivira Shale lies below a much more competent Drum limestone and part of the Chanute Shale. The Chanute Shale contains calcareous siltstone and sandstone and tests indicate a high crossbed shear strength. The width of the conduit section and transition zone is 300 feet. The outlet works are not perpendicular to the dam axis therefore the conduit section and transitions are at different locations upstream and downstream. The primary design

consideration in this reach was the Chanute shale underclay. Because of the large difference between the peak and residual values for the "S" strength not all factors of safety were above 1.0 using residual strengths. The stability was considered adequate because design strengths were conservatively picked and an analysis based on residual strengths is inherently conservative.

f. Left Abutment (Station 113+70 to Station 120+35). The height of the embankment in this reach varies from 67 feet to 0 feet. The upstream slope is 1 on 3 from top of dam to elevation 928.2, 1 on 8 to elevation 898.2, and 1 on 4 to the ground surface. The downstream slope is 1 on 3 from top of dam to elevation 929.0, 1 on 8 to the service road, and 1 on 3 to the ground surface. Between Station 114+70 and 115+70 the impervious section transitions into a zoned section with a random and berm zone. The upper breakpoint was raised and the slopes steepened to accomodate foundation conditions that are somewhat different in this reach.

5-05. Zoning. The zoning of the embankment was selected to make maximum use of materials from required excavations and to minimize the need for material from commercial sources, and to satisfy the requirements for stability and seepage control.

a. Impervious. A central impervious zone is used across the valley. This zone is larger than necessary to control through seepage and is so sized because impervious material is readily available. Impervious consisted of CL and CH overburden material as based on the Unified Soil Classification System in accordance with Waterways Experiment Station Technical Memorandum 3-357. Impervious upstream of the dam axis contains less than 5 percent gravel. Shale material was not permitted for impervious. Compaction requirements were at least 95 percent of maximum dry density as determined by the standard effort compaction test described in EM 1110-2-1906. Placement moisture contents were limited to a range of 3 percent above optimum to 2 percent below optimum.

b. Pervious. An inclined drain downstream of the impervious core and a horizontal blanket with stringers extending to the downstream toe were designed to intercept seepage through the embankment and control seepage as it exits the downstream portion of the embankment. The downstream blanket extends from Station 59+00 to Station 120+30 and is continuous to Range 1+00 downstream. Stringers 50 feet wide and 3 feet thick extend to the toe at Stations 90+00, 95+00, 100+00, and 105+00. The blanket is continuous on the left abutment from Station 111+70 to Station 120+30. The blanket is continuous on the right abutment from Station 59+00 to the top of the left stream bank of Big Bull Creek extending to the centerline of the existing gully or downstream toe. There is also a pervious drain on the downstream side of the cutoff trench which is buried from Station 44+82 to Station 75+00 on the right abutment and from Station 116+00 to Station 118+88 on the left abutment. From Station 75+00 to Station 116+00 the inclined drain in the cutoff trench is brought up to the pervious blanket. The inclined drains have a minimum horizontal thickness of 6 feet and the blanket has a minimum thickness of 3 feet. A one foot thick crushed stone filter was placed between the pervious drain in the cutoff trench and the face of the Drum Limestone and Iola Formation where joints up to 1/2 inch width existed. Compaction requirement was a minimum relative density of 70 percent.

c. Random. Random zones were provided for use of sandy or gravelly materials. Random material consists of overburden material, except OH, Pt, MH, and OL. Materials with liquid limit above 60 were not allowed in the random zone. Also shale materials were not permitted. Compaction and moisture control were the same as impervious.

d. Berms. Berms consist of shale and other material from required excavation which was unsuitable or in excess of the requirements for impervious and random. The outer portion of the upstream berm was constructed with CH material.

5-06. Seepage Control. By using embankment zoning, a cutoff trench, and a grout curtain, through seepage and underseepage will be controlled to prevent excessive water loss and to insure the safety of the embankment.

a. Through Seepage. Through seepage will be controlled by the combination of the impervious core and pervious drain. The impervious core will keep the quantity of through seepage small. The pervious drain will intercept any seepage that exits from the downstream face of the impervious core. This will insure that the phreatic line will remain well within the embankment and will not adversely affect the stability of the downstream slope.

b. Underseepage. Underseepage will be controlled by a cutoff trench across the valley. The cutoff trench was excavated through the Drum limestone across the valley. Pressure tested borings into the bedrock strata below the cutoff trench substantiate the strata are sufficiently impervious to prevent adverse seepage through the bedrock underlying the cutoff trench. The bedrock in the valley is overlain by 15 feet or more of clay for more than a mile up and downstream of the dam axis. An inclined pervious zone exists on the downstream side of the cutoff trench to intercept any underseepage and to act as a filter to prevent piping of the impervious material.

c. Abutment Seepage. Seepage through the abutments will be controlled by the curtain grouting and the upstream clay blanket on the right abutment. The cutoff trench was excavated into sound bedrock from Station 43+75 to Station 79+50. The cutoff trench extends to Station 121+00 on the left abutment. Some seepage through the abutments is possible, however such seepage will not adversely affect the safety of the project because any flow would have lengthy seepage paths through rock formations.

d. Grouting. Grouting verified that bedrock units are tightly jointed and relatively impermeable. Out of 500 holes drilled in the right abutment, grout was injected into 12 holes. Most of the grout was injected into a sandstone lense in the Chanute shale. In the left abutment grout was injected in 11 of 202 holes drilled. Most of the grout was injected into the limestones. Approximately 280 sacks of grout were injected into bedrock.

5-07. Selected Design Strengths. In selecting design values, stress strain compatibility, the relationship of maximum shear strength to ultimate shear strength, the number of tests, the nature of the material, and the location of the material with respect to potential failure surfaces, were all considered.

a. Adopted Foundation Strength.

(1) Foundation Overburden. The foundation overburden was divided into different reaches, and in the main valley the overburden was divided by layers of lean and fat clay.

(a) "Q" strength. For the abutments, a design "Q" shear strength of C = 0.90 t.s.f., tan ø = 0 was used. For the main valley, a design "Q" shear strength of C = 0.20 t.s.f., tan ø = 0.20 was used for normal stresses up to 3 t.s.f., and C = 0.80 t.s.f., tan ø = 0 for normal stresses above that. For the Little Bull area, a design "Q" shear strength of C = 0.1 t.s.f., tan ø = 0.10 was used for normal stresses up to 3 t.s.f., and C = 0.40 t.s.f., tan ø = 0 for normal stresses above that. Foundation "Q" strengths are summarized on Plate 50.

(b) "R" strength. For the abutments and main valley, a design "R" strength of C = 0.3 t.s.f., tan ø = 0.20 was used. For the Little Bull area, a design "R" strength of C = 0.1 t.s.f., tan ø = 0.2 was used. Foundation "R" strengths are summarized on Plate 51.

(c) "S" strength. For the abutments, a design "S" shear strength of C = 0, tan ø = 0.35 was used. For lean clays in the valley, a design "S" shear strength of C = 0, tan ø = 0.45 was used. And for fat clays in the valley, C = 0, tan ø = 0.35 was used. Residual "S" strengths of C = 0, tan ø = 0.25, 0.30, and 0.25 were also used for these respective cases. Foundation "S" strengths are summarized on Plate 49.

(d) Residual strengths. Although "residual" (large strain) "S" shear strengths based on test results for the foundation clays were used in the stability studies in DM 7, an examination of the safety factors and corresponding failure planes show the Quivira underclay to be the dominant factor. The critical failure planes are in each case along the Quivira and only cross through the foundation clays. Since the foundation clays are alluvial deposits they have been basically deposited horizontally. The residual "S" shear tests on these materials were conducted along a horizontal orientation also. As in the case of sedimentary rocks the horizontal shear strength is generally less than the "cross bed" shear strength. It is reasonable to assume this would be valid for the subject foundation clays also. Therefore, on the basis of orientation and the shorth length of the critical failure planes in the foundation clays the peak shear strengths in DM 7 were used in the stability studies with residual strengths for the Quivira shale.

(2) Foundation shales. The shear strengths used for the Quivira shale in the original design were a peak strength of tan ø = 0.21 and a residual strength of tan ø = 0.13. These strengths were based on the results of drained direct shear tests performed during the preparation of the embankment Design Memorandum. Limited test data were available as a basis for these design strengths, but it was believed that these were the only tests representative of a possible weak or soft zone in the Quivira Shale underclay. In later testing performed from samples obtained during exploratory work at the time the cutoff trench was excavated, only one test with a peak strength of tan ø = 0.20 approached the original peak design strength. All other test

results were significantly higher. The test data summary is presented on plates 57 and 58. After extensive exploration and testing failed to substantiate a continuous low strength zone in the Quivira Shale underclay a very conservative peak strength of tan ϕ = 0.21 was not changed, instead, redesign of the embankment used a reduced safety factor requirement. The testing of the Quivira shale had been directed at determining the strength of the suspected soft zone in the underclay, thus only the softer, worst case, samples were tested. Since the zone is discontinuous the residual shear strength conditions should not exist. Because of the discontinuity of the soft zone and the fact that the test program produced conservative strength values a design strength for analyses conducted for this report was selected such that two-thirds of the test values exceed the design value. The selected strength value was tan ϕ = 0.37.

b. Adopted Embankment Strengths. The strengths of the impervious, random, and pervious were assumed to be the same during design. The higher strength of the pervious zone was ignored to simplify stability analysis. A design "Q" strength of C = 0.70 t.s.f., tan ϕ = 0.0; a design "R" strength of C = 0.20 t.s.f., tan ϕ=0.18; a design "S" strength of C = 0, tan ϕ = 0.45 was used. The "Q" and "R" strengths correspond to the strength envelopes through points on the Mohr circle representing stresses on the failure plane. Record control testing during construction indicated the design strengths were conservative. The design strengths were obtained from testing remolded test specimens from the borrow areas. The prepared specimens were compacted to 95 percent which was the minimum condition allowed in the field. Material compacted to higher dry densities and dry of optimum, representing the actual field condition, should have higher strengths. A summary of the record control test data is presented in the following table.

TABLE 2

<u>Record Control Tests</u>

HILLSDALE R.C. TESTS

Material	"Q"		"R" $(\tau_{ff}$ vs $\bar{\sigma}_{fc})$		R$\left(\frac{\sigma_1-\sigma_3}{2} \text{ vs. } \frac{\sigma_1+\sigma_3}{2}\right)$		"S"	
	c, tsf	tan Ø	c, tsf	tan Ø	c, tsf	tan Ø	c, tsf	tan Ø
Rt. Abut Impervious Zone	1.45	0.00	0.65	0.24	0.62	0.20	0.00	0.46
Rt. Abut. Random Zone	1.43	0.00	0.66	0.22	0.58	0.20	0.0	0.46
Main Valley Impervious Zone	1.32	0.00	0.85	0.22	0.76	0.20	0.00	0.48
Main Valley Random Zone	1.00	0.00	0.44	0.32	0.35	0.26	0.00	0.46
Little Bull Impervious Zone	1.32	0.00	0.49	0.29	0.41	0.25	0.00	0.51
Little Bull Random Zone	1.33	0.00	0.55	0.28	0.46	0.24	0.00	0.47
Conduit Impervious Zone	1.30	0.00	0.39	0.33	0.31	0.27	0.00	0.52
Left Abut. Impervious Zone	1.30	0.00	0.73	0.31	0.64	0.25	0.00	0.47
Left Abut. Random Zone	1.08	0.00	0.76	0.42	0.56	0.33	0.00	0.57

The consolidated-undrained test data are presented showing strengths representing the envelope drawn tangent to the Mohr circles and strengths representing the shear strength at failure on the failure plane versus the effective normal consolidation stress on the failure plane. The latter strength envelope is more appropriate in stability analysis as a relationship between shear strength and effective normal or consolidation stress the failure plane prior to undrained shear.

c. <u>Adopted Design Strengths.</u> The following table presents the physical soil properties used in reevaluating the stability of the embankment.

TABLE 3

PHYSICAL SOIL PARAMETERS

Material	Unit Weight (pcf) Saturated	Drained	"Q" c (tsf)	Tan Ø	"R" c (tsf)	tan Ø	"S" c (tsf)	tan Ø
			Lower Right Abutment (Station 81+00)					
Berm	115	110	0.10	0.10	0.10	0.20	0.00	0.35
			0.40	0.00				
Random	125	120	1.43	0.00	0.66	0.22	0.00	0.46
Impervious	125	120	1.45	0.00	0.65	0.24	0.00	0.46
Foundation Clay	115	110	0.20	0.20	0.30	0.20	0.00	0.45
			0.80	0.00				
Quivira Shale	140	-	-	-	-	-	0.00	*0.21
			Main Valley (Station 90+00)					
Berm	115	110	0.10	0.10	0.10	0.20	0.00	0.35
			0.40	0.00				
Random	125	120	1.00	0.00	0.44	0.32	0.00	0.46
Impervious	125	120	1.32	0.00	0.85	0.22	0.00	0.48
Foundation Clay, CH	115	110	0.20	0.20	0.30	0.20	0.00	0.35
			0.80	0.00				
Foundation Clay, CL	115	110	0.20	0.20	0.30	0.20	0.00	0.45
			0.80	0.00				
Drum Limestone	165	-	-	-	-	-	0.00	0.70
Quvira Shale	140	-	-	-	-	-	0.00	*0.21
			Little Bull Area (Station 104+00)					
Berm	115	110	0.10	0.10	0.10	0.20	0.00	0.35
			0.40	0.40				
Random	125	120	1.33	0.00	0.55	0.28	0.00	0.47
Impervious	125	120	1.32	0.00	0.49	0.29	0.00	0.51
Foundation Clay, CL	115	110	0.10	0.10	0.10	0.20	0.00	0.45
			0.40	0.00				
Drum Limestone	165	-	-	-	-	-	0.00	0.70
Quivira Shale	140	-	-	-	-	-	0.00	*0.21

*Quivira shale strength revised to C = 0.00 tsf and tan Ø = 0.37 which represents an envelope through the lower one-third of the record control test results.

5-08. Stability Analysis. The The stability analysis of the original embankment design is presented in Design Memorandum No. 7, *Soil Data and Embankment Design*, Appendix B. The analysis was performed with a computer program compatible with the wedge method of analysis presented in EM 1110-2-1902 with two exceptions. The slope of the "side" force was assumed to be constant throughout the active wedge, and the angle of the failure plane was

assumed to be the same for each material in the active wedge. The analytical cases used in design were the end of construction condition for the upstream and downstream slopes, sudden drawdown and partial pool conditions for the upstream slope, and steady seepage condition for the downstream slope. Earthquake safety factors were checked for the partial pool, steady seepage and construction cases.

a. Design Assumptions. The higher strengths of the pervious zone and the cutoff trench were not used in the analysis. These are conservative and simplifying assumptions. For the end of construction case it had been assumed consolidation during construction was negligible and the line of saturation was at the ground surface. For the partial pool cases it was assumed the line of saturation to be horizontal at the pool elevation, considered. For the steady seepage case it was assumed the lake elevation to be at the spillway crest which is conservative in that this is the maximum pool that can be stored. For steady seepage at maximum surcharge pool, no additional saturation was assumed. Vertical equipotential lines were assumed. Sudden drawdown cases assumed the embankment was saturated to the upper pool limit and the pool was lowered to multipurpose pool instantaneously with no drainage of pore water.

b. Embankment Stability. The embankment was analyzed at various locations representing differing foundation conditions existing at the site. The stability analyses for the lower right abutment, main valley, Little Bull area, outlet works section, and left abutment are summarized on plates 59 to 63. Revised conduit location and conduit embankment section required a reanalysis of the outlet works section (plate 64). The designed embankment was based on the assumption that a "weak" zone or seam in the Quivira underclay was continuous across the entire valley. Since the continuity of seam was uncertain it was decided to retain the original design with the provisions to redesign the embankment after an evaluation of the Quivira underclay.

(1) Embankment redesign. Based on the extensive number of explorations and laboratory shear tests it was concluded that the "weak" zone in the Quivira underclay was not continuous or extensive. However, rather than discount the presence of this weak layer by choosing a higher design strength, it was believed to be more appropriate to use a very conservative peak strength and require a reduced safety factor. The embankment section was revised to provide an approximate safety factor of 1.4 for the steady seepage and partial pool cases. Although the safety factors for the end of construction, earthquake, and rapid drawdown cases were checked, the resulting safety factors did not influence the revised embankment. Normally a minimum 1.0 safety factor for the earthquake case is considered desirable. However, in view of recent developments in earthquake engineering which indicate the pseudo-static method of determining earthquake safety factors does not adequately take into account soil dynamic strength. However, the design strength safety factors around 1.0 for the earthquake case, are adequate since none of the materials are potentially liquefiable. Considering the improbability of residual shear conditions for a rapid drawdown case, those safety factors were not considered significant for the revised embankment section. Three embankment stations were selected for stability analyses: Staton 81+00, 91+00, and 104+00. (See plates 65, 66 and 67 for details.) The revised section safety factors shown in color on the above plates are as follows:

TABLE 4

Design Memorandum Stability Studies

Station 81+00	Peak Streangth Safety Factor	DM Supplement Residual Strength Safety Factor
End of construction	1.72	-----
Rapid drawdown from spillway crest	1.21	-----
Partial pool	1.41	1.10
Steady seepage	1.39	1.00
Earthquake	1.05	-----
Station 90+00		
End of construction	1.68	-----
Steady seepage	1.40	1.02
Earthquake	1.00	-----

Note: Upstream embankment was constructed in Stage I, therefore, upstream safety factors apply as shown in the original DM 7.

Station 104+00		
Construction halt Elev. 930.2	1.39	-----
Rapid drawdown from spillway crest	1.21	-----
Partial pool	1.44	1.13
Steady seepage	1.39	1.02
Earthquake	1.00	-----

(2) Stability reevaluation. For this report, the embankment stability was reevaluted basei on as built conditions. Stability analyses during design assumed excess pore pressure from construction had dissipated in the embankment and foundation shales for the partial pool and steady seepage cases. Actual instrumentation data indicates the upstream overburden is saturated with a piezometric surface that reflects the pool elevation. Excess pore pressures have not dissipated either in the impervious zone nor in the Quivira shale. The embankment was analyzed for the steady seepage and partial pool cases using present construction induced pore pressure levels.

(a) Method of analysis. The computer program used for design does not facilitate the analysis of uplift forces in the foundation. A computer program, SSTAB1-BR. developed for the Bureau of Reclamations by Stephen G. Wright. University of Texas, Austin. was used because it can analyze a noncircular failure surface with a phreatic surface in the embankment and pore water pressures in the foundation. SSTAB1-BR uses Spencer's procedure to calculate the safety factor for specified noncircular slip surfaces. It is a special solution of the Morgenstern and Price method in which all the interslice side forces are assumed to have the same inclination. The program satisfies all conditions of equilibrium. The two

unknown parameters, F, (the safety factor) and theta, θ, (the side force inclination) are varied simultaneously. By iteration, a convergent solution is found with the net force and moment imbalance less than specified values. The method does not compute the same safety factor as the wedge analysis prescribed in EM 1110-2-1902. The side forces are inclined throughout the failure block using Spencer's procedure, while only the earth force in the active wedge is inclined in the wedge analysis. A hand wedge analysis using the inclined side forces from SSTAB1-BR for the steady seepage case at station 81+00 resulted in a safety factor of 1.62. A hand study using the EM prescribed wedge method resulted in a safety factor that was 0.2 less than Spencer's safety factor.

(b) Safety factors. The embankment sections considered in the redesign analyses were evaluated for the partial pool, rapid drawdown and steady seepage cases. Increased embankment strengths based on record control test results were used with the design foundation strengths. Quivira shale strength was C=0. tan Ø=0.21. The reevaluated safety factors are shown in the following table.

TABLE 5

Stability Studies Using Embankment Strengths from Record Control Tests And Design Foundation Strengths

Case	DM Supplement Safety Factor (Required)	Safety Factor (From Studies)
Rapid Drawdown (from Spillway Crest)	1.2	1.39
Rapid Drawdown (from Maximum Surcharge)	1.0	1.30
Partial Pool (Sta. 81+00)	1.4	1.54
Steady Seepage (Sta. 81+00)	1.4	1.13
Steady Seepage (Sta. 90+00)	1.4	1.15
Steady Seepage (Sta. 104+00)	1.4	1.15

The rapid drawdown and partial pool cases indicated higher safety factors. The steady seepage cases showed lower factors of safety. The factors of safety obtained were considered very conservative because the foundation strengths were obtained to reflect the fact that the soft zone in the Quivira shale is continuous. Therefore, the Quivira shale strength was revised to represent an envelope where two-thirds of the test values exceeded the envelope. The revised foundation strength (tan Ø=0.37) resulted in the following factors of safety.

TABLE 6

Stability Studies Using Embankment Strengths From
Record Control Tests And Revised Foundation Strengths

Case	Safety Factor (Required)	Safety Factor (From Studies)
Rapid Drawdown (from Spillway Crest)	1.2	2.00
Rapid Drawdown (from Maximum Surcharge)	1.0	1.90
Partial Pool (Sta. 81+00)	1.5	2.17
Steady Seepage (Sta. 81+00	1.5	1.63
Steady Seepage (Sta. 90+00)	1.5	1.64
Steady Seepage (Sta. 104+00)	1.5	1.69

The most critical case was steady seepage at Station 81+00. This section occurs in the closure area where the excess pore pressures from construction are the highest. The calculated factor of safety is above the required 1.5 and will continue to increase as the pressures in shale continue to dissipate. This critical case was evaluated by a hand wedge analysis that yielded a safety factor of 1.62.

5-09. Settlement. Settlement analyses, based on condolidation tests, were run on the foundation overburden. The maximum total settlement in the valley was anticipated to be 1.5 feet. Settlement analyses of the embankment were not performed because experience indicates there will be very little consolidation of the embankment after construction. Settlement plates were installed in the foundation overburden to monitor foundation settlement during and after construction. Crest settlement monuments were also installed on the crest of the dam to measure post construction settlement. The settlement plates show a maximum of 1.4 feet of settlement with over a foot occurring during construction. The crest settlement monuments indicate uniform settlement of less than 0.2 feet.

5-10. Slope Protection. Requirements for upstream slope protection were investigated for three separate segments of the dam. Fetches for each segment were determined in accordance with the radial fetch method as described in Technical Memorandum No 132. Wave heights were selected in accordance with Technical Manual No. 132. Overland wind velocities were determined from a wind analysis of records for Topeka, Kansas over a 23 year period. A 50 m.p.h. wind velocity was used to size the stone protection at multipurpose

pool to reduce some of the inherent risks in the area of frequent pool levels. "The Criteria for Riprap Wave Protection in Missouri River Division," dated June 1974, were generally used for riprap slope protection design. Riprap design data is shown on Plate 17.

CHAPTER 6

CONSTRUCTION HISTORY

6-01. General. The Hillsdale embankment was built under three contracts supervised by the Kansas City District, Corps of Engineers. The Contractor for the Stage I contract was J. A. Tobin Construction Company, Kansas City, Kansas. Cutoff trench, outlet works channel and diversion channel were excavated and part of the embankment was constructed under this contract. Stage I work started in April 1976 and was completed in December 1977. The Stage II Contractor was Southwest Construction Corporation, Oklahoma City, Oklahoma, work was initiated in June 1977 and completed in May 1980. The outlet works were constructed under the Stage II Contract. The embankment was completed under the Stage III Contract, work began in July 1978 with the completion of the embankment in July 1982.

6-02. Modifications. The following modifications were made to the contracts.

TABLE 7

Modifications

Stage I

Modification No.	Subject
P00001	Pervious and Filter Material Changes
P00002	Time Extension Due to Weather Delays
P00003	Time Extension Due to Weather Delays
P00004	Time Extension Due to Weather Delays
P00005	Time Extension Due to Weather Delays
P00006	Unit Price of Cutoff Trench Cleanup Class I.

Stage II

Modification No.	Subject
P00001	Excavation for Pier
P00002	Time Extension Due to Ironworkers Stike and Weather Delays
P00003	Bubbler System
P00004	Handrails and Kickplates for Intake Tower
P00005	Electrical Work and Lightening Protection
P00006	Time Extension Due to Weather Delays
P00007	Electrical Work
P00008	Time Extension Due to Weather Delays
P00009	Test Holes in Conduit Monolith Nos. 2 and 3

TABLE 7 (continued)

Stage II (continued)

Modification No.	Subject
P00010	Time Extension Due to Weather Delays
P00011	Hydraulic Pipe Support Brackets, Valves, and Pulley Assembly for Emergency Gate
P00012	Emergency Gate Crane Bumper Plates
P00013	Administrative Change of Contractors Address
P00014	Time Extension Due to Weather Delays
P00015	Emergency Gate Storage Bracket and Lifting Beam Ring
P00016	Administrative Change of Payment Office
P00017	Additional Conduit Roof Form
P00018	Time Extension Due to Weather
P00019	Administrative Change of Contractors Address
P00020	Suspension of Work on the Tower
P00021	Administrative Change of Contractors Address
P00022	Constructive Welding Changes

Stage III

Modification No.	Subject
P00001	Well - Plugging
P00002	Lightening Protection Work
P00003	Grouting Spring at Outlet Works, Sta. 55+50
P00004	Castle Dimensions on PYLON DETAIL
P00005	Culvert Length of Outlet Works Road 2, Sta. 1+65
P00006	Crest Elevation of the Upstream Cofferdam
P00007	Time Extension Due to Weather Delays
P00008	Deletion of Requirement to Obliterate South Access Road
P00009	Well - Plugging, Well No. 5 and 10
P00010	Construction of Upstream Rock Service Road
P00011	Service Bridge Abutment Fill
P00012	Deletion of Required Timber Clearing
P00013	Culvert for South Access Road, Sta. 101+00
P00014	Time Extension due to Weather Delays

TABLE 7 (continued)

Stage III (continued)

Modification No.	Subject
P00015	Wash Checks in Ditch of North Access Road, Concrete Ditch Liner for Toe Service Road, and Earth Cover Over Pervious Wick.
P00016	Stoplogs, Apertures, Trash Racks, and Lifting Beam Remedial Work
P00017	Administrative Change of Payment Office
P00018	Guardrails for Toe Service Road
P00019	Electrical Work
P00020	Time Extension Due to Weather Delays
P00021	Extension of South Access Road Bituminous Surfacing
P00022	Bituminous Tack Coat
P00023	Pavement Markings for the South Access Road, Dam Road, and North Access Road
P00024	Additional Costs due to Non-availability of Work Areas and Delay of Diversion
P00025	Crushed Stone Base Course Quanities

Modifications significant to the performance on construction of the embankment are discussed below.

a. Modification P00001. This change to the Stage I contract was necessary to insure adequate seepage control in the areas where the Chanute and Lane shales existed in the cutoff and to insure adequate seepage control in the areas where the jointed structures of the Drum and Raytown limestones existed in the cutoff trench. This change consisted of the following:

(1) Pervious fill was placed against the Raytown limestone in the left abutment area.

(2) From approximately Station 106+40 to 112+30, the bottom of the cutoff was widened and pervious was placed against the downstream side of the trench. The pervious formed a drain extending to the ground surface.

(3) From approximately Station 71+90 to 79+15, the bottom of the cutoff trench was widened and pervious was placed against the downstream side of the trench. The pervious formed a drain extending to the ground surface, but not above Elevation 900.0 in the area where none was encountered.

(4) From Station 44+50 to 71+90, pervious was placed to a height of two feet above the top of bedrock on the downstream slope of the cutoff trench.

(5) From approximate Station 79+00 to 106+50, a one foot horizontal width of crushed stone filter material was placed against the Drum limestone on the downstream side of the cutoff trench.

(6) A one foot horizontal width of crushed stone filter material was placed between the Raytown limestone and the pervious drain where open joints exceeded one-fourth inch in width.

b. Modification P00006. This change to the Stage III contract required the elevation of the upstream cofferdam to be raised from Elevation 895.0 to 906.0. The change was made as a result of additional hydrologic studies indicating inadequate overtopping protection.

c. Modification P00010. This modification to the Stage III contract provided an upstream service road on the embankment for access to observation devices and access to the upstream slope for repair of potential wave damage.

d. Modification P00015. This modification to the Stage III contract required a 1-foot cover over the pervious drain in the closure area during the 1980-1981 winter shutdown to prevent contamination of the pervious material. The earth cover was compacted and shaped to drain away from the drain. The cover was removed and the pervious material was cleaned with to top lift being recompacted the following spring.

6-03. Cutoff trench.

a. Excavation. Cutoff trench excavation was characterized as overburden, Class I, or Class II rock. The Contractor was required to determine the suitability for usage in the embankment at the time of excavation with unsuitable material to be placed in diversion dikes or channel fill stockpiles. The cutoff trench excavation was maintained in the dry during excavation, cleanup, grouting, and backfilling. Blasting operations and methods of ripping were controlled so that the gradations of the materials were suitable for use in the embankment. Slopes, 1 on 1 or steeper, in bedrock were presplit or sawed, the Quivira shale in the cutoff trench was required to be sawed. The approximate limits of the cutoff trench were shown on the construction drawings with the actual limits determined from the condition of the bedrock.

(1) Cutoff trench in limestone formations. Within the cutoff trench on each abutment, the upper surface of the Iola and Drum were completely exposed prior to removal of any portion of the formation. Rock excavation was completed prior to construction of the grout curtain.

(2) Cutoff trench in shale formations. Excavation was continued to a depth necessary to remove all desiccated, deteriorated, fractured, and weathered rock that was determined to be unsatisfactory. Equipment used in the material was mounted on rubber tires to prevent damage to the final bedrock surface. Excavation of shale was a continuous operation to the final depth except where grouting on shale surface (station 106 to station 115) resulted in 3 to 5 feet of Chanute shale being excavated after grouting.

Within 24 hours after exposure, final bedrock surfaces were cleaned, inspected and backfilled with a minimum of 12 inches of embankment material. During the period of exposure, bedrock surfaces were sprayed with water as needed to prevent drying. Within 48 hours after exposure three feet of embankment material was required to be placed. The length of the reach of the trench that was allowed to be open was restricted to the length that could be excavated, cleaned, inspected, and embankment placed as required.

b. Cutoff trench cleanup. Cleanup of the bedrock surface was performed on the floor and where directed on the bedrock portion of the sideslopes. Cleanup consisted of removing unsound, fractured or loose rock, and other objectionable material. Cleanup was accomplished by barring, picking, brooming, and when directed, by use of air-water jetting. All overhangs, cavities or large joints, and irregularities in the bedrock were cut back, excavated, and backfilled with pervious or filled concrete.

c. Grouting. Preliminary investigations prior to construction indicated that a single line grout curtain was needed in both abutments. Grouting was performed from the floor of the cutoff trench on bedrock. Grout holes were drilled with a pneumatic rotary drill using 2 1/2 inch diameter non-coring bits. All holes were drilled, washed, pressure tested, and grouted in stages from the top down. Primary holes were drilled on 20-foot centers with secondary holes midway between and tertiary holes midway between the primary and secondary holes. The holes were inclined landward 30 degrees and 45 degrees from vertical. Some holes were drilled parallel to the dam axis, some were directed upstream 45 degrees and some 65 degrees. The grout consisted of 3 cubic feet of water and 1 cubic foot of cement. Grouting verified that bedrock units in the abutments are tightly jointed and relatively impermeable. Out of 500 holes drilled in the right abutment, grout was injected into 12 holes. Most of the grout was injected into a sandstone lense in the Chanute shale. Approximately 260 sacks of grout were injected, mostly in four of the 12 holes. In the left abutment out of 202 holes drilled, 19.4 sacks of grout were injected into 11 holes. Most of the grout was injected into the limestones. A total of approximately 280 sacks of grout were injected into bedrock and 1,205 sacks were used for backfill. Grout hole drilling totalled 22,699 lineal feet. A grouting summary is shown in Table 8.

TABLE 8

Summary of Grouting

Left Abutment	Lineal Feet Drilled	Sacks of Grout Injected
75 Primary Holes	2,473	11.0
74 Secondary Holes	2,250	8.4
53 Tertiary Holes	1,232	0
202 TOTAL	5,955	19.4

TABLE 8 (continued)

Right Abutment	Lineal Feet Drilled	Sacks of Grout Injected
168 Primary Holes	5,732	148.7
166 Secondary Holes	5,590	105.13
166 Tertiary Holes	5,377	6.0
500 TOTAL	16,699	259.83

BACKFILL: - 1,205 Sacks

$$\frac{279.23 \text{ Sacks}}{22,699 \text{ Lineal Feet}} = 0.0123 \text{ Sacks Per Foot of Hole}$$

Right Abutment Grout Curtain Extension
Station 77+00 to Station 79+40

13 Primary Holes	499	0.8
12 Secondary Holes	455	0
1 Tertiary Hole	50	0
26 TOTAL	1,004	0.8

Conduit Grouting

6 Primary Horizontal Holes at station 59+62.5	150	27
4 Primary Radial Holes at station 60+00	96	0
10 TOTAL	246	27

d. Changes as a Result of Construction Experience. A reach of the grout curtain, Station 76+00 to Station 79+45 was deleted from the Stage I contract because a large detached block of sandstone was discovered in the right abutment area. Because blasting was required to remove the block, grouting of this reach was deferred to the Stage III contract. Evaluation of the foundation, during Stage I particularly the Quivira shale and Raytown limestone, as a result of the construction of the cutoff trench lead to redesign of the embankment and modifications to the cutoff trench and previous drain.

6-04. Outlet Works. The outlet works as described in paragraph 2-04 was constructed under the Stage II contract with excavation initiated in August 1977. The entire outlet works are founded on the Chanute shale. Special surfaces and bearing surfaces, surfaces with slopes 1 on 1 or steeper which concrete was placed against, were excavated to leave the surfaces as nearly undisturbed as possible. Materials outside the excavation lines and grades indicated on the drawings was replaced with fill concrete. Excavation of the last 2 feet for special surfaces was performed immediately prior to placing concrete. Approach and outlet channel profile and sections and conduit grouting details are shown on Plate 22. Progress of construction under the Stage II contract fell behind resulting in scheduling problems during Stage III.

6-05. Embankment Construction. The embankment was constructed under the Stage I and Stage III contracts from materials obtained from required excavation and supplemented from upstream borrow. All suitable materials obtained from required excavation were used in the embankment. Unsuitable materials excavated in order to obtain suitable borrow material were used in channel fill, diversion dike or wasted back into the valley borrow areas.

a. Foundation Treatment. Prior to placement of fill the foundation was cleared of depressions by flattening the slopes of the depressions and filling them with compacted layers of material appropriate for the embankment zone in which they were located. Existing wells in overburden were backfilled with impervious material and wells in bedrock were grouted. Earth foundation areas were thoroughly stripped and loosened by plowing or discing to a depth of 8 inches. Roots and other debris uncovered in the process of loosening were removed and then the foundation was compacted with a rubber-tired roller or other heavy loaded rubber-tired equipment. When fill was constructed against an existing earth slope it was processed through the loose or dried material on the surface so that the existing material and the new fill was bonded together.

b. Embankment Materials.

(1) Impervious material consists of CL and CH (liquid limit not more than 60) overburden material as based on the Unified Soil Classification System in accordance with Waterways Experiment Station Technical Memorandum 3-357. Impervious material placed upstream of the dam axis contains less than 5 percent gravel. There is no shale material in the impervious material. Impervious in the conduit area consists of CL material only. There were no liquid limit restrictions on the impervious dike section on the right abutment.

(2) Pervious was Kansas River sand obtained from approved commercial sources. The material was required to be clean free-draining, durable, natural sand within the following gradation ranges as determined by washing over the specified sieves.

Sieve size	Percent by weight passing
No. 4	90-100
No. 16	55-85
No. 50	5-20
No. 200	0-5

(3) Random consists of overburden material. except OH. Pt, MH. and OL, from required excavation. Shale material was not allowed in the random zone. Materials with liquid limit above 60 were not used in the random zones except the outer 5 feet of the upstream slope below Elevation 942.2 which was required to be CH material with no restrictions on liquid limit.

(4) Berm material consists of shale and other material from required excavation which was unsuitable or in excess of the requirements for impervious and random.

(5) Clay blanket consists of CH material obtained from required excavation and supplemented with CH material from borrow.

c. Placement. Fill was not placed on any part of the embankment foundation until the area had been inspected and approved. All embankment material, except material for the diversion dike and channel fill was placed and compacted in the dry. No frozen material was allowed to be placed in the embankment. Fill was not allowed to be placed on or above frozen material. Water was not allowed to pond on the embankment and the surface was maintained so that construction equipment was able to travel on the embankment. The top surface of the fill within any zone was maintained approximately horizontal, except as otherwise approved. The differential in height of fill at the contact between adjacent zones of the embankment was limited to 3 feet. During construction, the embankment was sloped with grades not steeper than 5 percent and not less than 2 percent to facilitate surface drainage. Compacted fill adjacent to the pervious was maintained so that the compacted pervious fill was not below the adjacent support fill. Immediately after compaction of the pervious additional pervious fill was palced to maintain the uncompacted fill above the adjacent fill. Materials disturbed after compaction were reprocessed and recompacted. Materials were distributed throughout the embankment so that the fill was free of lenses, pockets, streaks, and layers of amterial differing substantially in texture or gradation from the surrounding material of the specified type. The travel distance of hauling equipment across the surface prepared for material placement was kept to a minimum. Successive loads of material was dumped at locations on the fill as directed or approved by the Contracting Officer. Material was spread in approximately horizontal layers. In zones where materials were adjacent to zones of significantly coarser materials, the coarse materials were sufficiently well graded to provide filter action so the fine material would not infiltrate into the voids of the coarse material. In general material was distributed in the impervious zone so that the more impervious materials were placed upstream of the axis of the dam. The more gravelly clays and less impermeable materials were placed downstream of the axis of the dam. In general, the more impermeable of the random material was placed adjacent to the impervious zone and the more permeable random was placed in the outer portion of the random fill. Whenever the surface of any layer developed ridges, or bridged, or became to smooth to bond properly with the succeeding layer it was loosened by scarifying before the next lift was placed. When a rubber-tired roller was used each lift surface was scarified prior to placement of the next lift. Before any layer was roller, it was processed by disking to the depth of the uncompacted layer thickness. When the surface became unduly wet or dry, it was processed and rerolled. Frozen fill was disked and properly recompacted before additional material was placed. This same procedure was used then the surface had cracked due to drying, had softened due to an increase in surface moisture content, and when tying into a previously built portion of the embankment. When the work was stopped on an area, it was smooth-bladed and sealed with either rubber-tired or smooth-wheel rollers to prevent absorption of rainfall and to facilitate drainage.

d. Compaction. The embankment was constructed to the following minimum compaction criteria. A procedure specification was used to meet these criteria.

TABLE 9

Compaction Criteria

Material	Criteria
Impervious fill	95 percent maximum dry density (standard effort)
Random fill	95 percent maximum dry density (standard effort)
Pervious fill	70 percent relative density
Berm fill	Compaction by rubber-tired roller

Compaction equipment, layer thickness, and number of passes for the various materials were specified with additional passes required as directed to obtain the desired compaction. A complete pass consisted of complete coverage of the area to be compacted with each trip of the roller overlapping the adjacent trip by not less than 2 foot. The specified compaction requirements are as follows:

TABLE 10

Compaction Procedure

Type of fill and compaction equipment	Maximum uncompacted lift thickness (inches)	Minimum number of passes
Pervious		
Plate vibratory compactor	6	As required to obtain specified relative density
Vibratory rollers	12	3
Impervious #		
Tamping roller	8	6
Random and clay blanket		
Tamping roller	8	6
Rubber-tired roller	12	3
Berm		
Rubber-tired roller	24	2
Diversion dike	24	Traffic compacted

TABLE 10 (continued)

Type of fill and compaction equipment	Maximum uncompacted lift thickness (inches)	Minimum number of passes
Special backfill		
Power tamper	3	As required to provide compaction equivalent to adjacent embankment material
Channel, waste, and area fills	No. max.	None required
Rock fill	36	None required

#When placed over a rock foundation, the lift thickness shall be 6 inches and compaction shall be two passes with a rubber-tired roller until the impervious zone reaches 18 inches thickness over the rock foundation. If the rubber-tired roller causes breakage of shale foundation, the ballast shall be lessened or the use of other rollers may be used as approved by the Contracting Officer.

The following list of equipment used during the construction of the embankment includes the compaction equipment.

TABLE 11

Equipment Used for Embankment Construction

Make	Model	Equipment	Number	General use
Hercules	WSX83-60120	Sheepsfoot Roller, 40,000 lb.	2	Soil compaction
Gebhard	#22	Sheepsfoot roller, 48,000 lb.	1	Soil compaction
Hyster	455A	Self propelled sheepsfoot roller, 49,000 lb.	1	Soil compaction
Ferguson	Rt-100S	Pneumatic roller, 100,000 lb.	2	Soil compaction
Raygo	320A	Vibratory roller, 14,340 lb.	1	Pervious fill compaction
Raygo	410A	Vibratory roller, 21,400 lb.	1	Pervious fill compaction

TABLE 11 (continued)

Make	Model	Equipment	Number	General use
Mikasa Sanlya	MVC-300G	Hand operated vibrator, 500 lb.	1	Pervious fill compaction
Ground Pounder		Hand operated compactor, 200 lb.	1	Pervious fill compaction
		Crane operated drop hammer	1	Backfill compaction adjacent to structure
Caterpillar	657B & 631	Scrapers	14	Borrow material excavation and haul
(Various)		Rear dump haulers		Borrow material haul
Euclid	B-70	Bottom dump haulers, 40 cu yd	17	Borrow material haul
Holland		Mobile belt loaders	2	Borrow material excavation
		Water trucks	2	Saturating pervious fill
Grade-All	1100	Gradall	1	Cutoff trench excavation & riprap placement

Additional equipment used include motor graders, bulldozers, bucket loaders, backhoes, dragline, and disks.

The Raygo 320A vibratory roller did not meet the specifications for weight, drum diameter, or drum width, however it was approved based on test data verifying the desired density could be obtained with this roller. Bedrock irregularities in the foundation and bedrock slopes under compacted impervious fill and adjacent to concrete structures required special compaction techniques to insure compaction was equivalent to adjacent embankment material. Compaction of the backfill along the conduit was obtained by air operated "powder puffs," a crane operated drophammer and wheel rolling with a rubber-tired loader.

e. Moisture Control. The upper limit of moisture content was 3 percent above the optumum moisture content and the lower limit was 2 percent below optimum for the impervious and random material. Material placed on the embankment with a moisture content exceeding 3 percent above optimum was spread and permitted to dry, assisted by disking as necessary, until the

moisture content was uniform and reduced to within the limits. Material placed with a moisture content less than 2 percent below optimum was sprinkled on the fill and worked with disks until the moisture content was within the required limits. Water applied to the fill was controlled so that free water would not appear on the surface during or subsequent to rolling. The pervious material was required to be wetted as necessary to facilitate compaction. Pervious material was maintained essentially saturated during compaction. Moisture content was controlled to the extent required to facilitate movement of compaction equipment.

f. Construction Control Procedures. The quality of the construction was controlled through a contractor quality control program and the government's quality control program and the government's quality assurance sampling and testing procedures.

(1) Quality Control. The contractor established a quality control system to maintain quality of his work as well as that of his subcontractors and to maintain compliance with the plans and specifications.

(2) Quality Assurance. Control tests were conducted by the government to verify the quality of the embankment. Testing was performed in accordance with Engineering Manual EM 1110-2-1906, Laboratory Soils Testing, and Hillsdale Lake specifications, and Hillsdale Lake field and laboratory testing manuals.

(a) Impervious and Random Fill. The most important control feature for the impervious and random fill was the moisture content range. This range was specified to have an upper limit of 3 percent above optimum and a lower limit of 2 percent below optimum. Materials placed at a moisture contents within this range and using the specified lift thickness and number of passes should have dry densities not less than 95 percent of maximum. During Stage I and Stage III construction over 1600 sand cone density tests were performed to insure that this criteria was being met. Plate 75 shows the moisture content results from these field tests by showing plots of Deviation From Optimum Moisture Content vs. Number of Tests. Material which did not have moisture contents within the specified range or did not have dry densities of at least 95 percent of maximum, were generally reworked. Maximum dry density and optimum moisture content were determined by the standard compaction test. Prior to and during construction, a large number of 5 point compaction curves were established. To determine the compaction curve applicable to a particular field test, a one point compaction test run on the material at a moisture content slightly below optimum. Most of these field tests included a liquid limit, and occasionally a plastic limit determination. In addition to the field density tests, 211 record control samples were taken. These samples were sent to the MRD Laboratory for more extensive testing to check the physical properties assumed for design. Results from both the field control tests and the record control tests are presented in plates 70 through 151.

(b) Berm Fill. The only moisture content control for the berm fill was the ability of the roller to travel on it. No record control tests and a very limited number of field density tests were taken on this fill material.

(c) Pervious Fill. The compaction criteria for the pervious fill was based on a relative density of 70 percent. The field density tests consisted of both the sand cone method and the nuclear method. Along with each field density test a mechanical analysis was performed to insure that the gradation fell within the range specified.

(d) Undisturbed Samples. Samples were obtained for record control testing. Sampling procedure involved excavating down to a pervious lift leaving a smooth surface, and pushing a 6-inch diameter cylinder into the compacted material. Undisturbed samples of the embankment were also obtained using the 5-inch Shelby tube sampler.

6-06. Spillway. The spillway was excavated as shown on Plate 15. Excavation was accomplished by scrapers and dragline with the excavated material placed in dike section on the upper right abutment. Subsequent to completion of construction erosion of the spillway side slopes indicated the possibility of dispersive clay in the spillway subsequent laboratory conformed the dispersive clay. Evidence of the dispersive clay in the dike section cannot be found. The spillway was excavated into the Lane shale where moisture content required excavation by dragline and some of this material was placed in upstream berms section.

6-07. Diversion and Closure. The diversion channel as shown on Plate 7 was excavated during Stage I to divert Little Bull Creek to Big Bull Creek. The embankment was constructed to a minimum elevation of 913 prior to diversion. Final diversion through the outlet works followed the following sequence of events. Excavation of approach and outlet channels, except channel blocks were completed and riprap was placed in the outlet channel. The upstream and downstream channel blocks in the outlet works channel were removed, with the upstream plug removed last. A construction haul road across Big Bull Creek was used for the diversin dike. Foundation preparation included much excavation, stream bank excavation and cleanup of bedrock in the closure area. Stream banks were excavated to 1 on 3 slopes concurrently with placement of channel fill upstream of cofferdam. Upstream cofferdam was constructed to Elevation 906.0 and downstream cofferdam to Elevation 873. Excavation, cleanup and grouting was completed. Closure was made in 15 June 1980.

CHAPTER 7

INSTRUMENTATION

7-01. General. Embankment instrumentation was installed during construction to provide movement measurements, pore water pressure measurements both in the foundation and embankment, and groundwater levels for use in evaluating the performance of the dam. The Contractor was responsible for the installation of some of the devices and some were installed by the government. Six types of observation devices were installed in the embankment: open tube piezometer devices, air-operated piezometer devices (pressure cells), inclinometers, foundation settlement devices, alinement monuments, and crest settlement monuments. Construction sequence, topography, and geology were considered in locating each device. Plate 152 shows the location of each device. One line of piezometers was located in the closure area, a second line across the main valley area, and a line in the Little Bull Creek channel area. Additional piezometers are located in the abutments.

7-02. Piezometers.

a. Air-operated Piezometers. There are 14 air-operated piezometers installed, 1 in the embankment, 6 in the overburden, and 7 in the foundation. Generally, the air cells indicate the upstream overburden is saturated, and the Drum limestone is fairly open allowing water to reach the Quivira shale with little headloss. The foundation air operated piezometers are located in the upper portion of the Quivira shale directly below the Drum limestone and they show a fairly rapid response to pool fluctuations.

b. Open Tube Piezometers. There are 52 open tube piezometers and 4 foundation settlement gages with open tube piezometers isntalled, 12 in the embankment, 13 in the overburden (including settlement gage piezometers), and 31 in the foundation.

c. Performance. It is suspected that the fluctuation with the pool of the upstream piezometers in the Quivira is a result of influence from seepage through the limestone layer overlying the shale. This is supported by the fact the upstream piezometric levels of piezometers whose tips are located deeper in the Quivira do not respond as quickly or as high as those closer to the limestone. The piezometers in the Quivira downstream of the dam axis do not fluctuate with the pool. Piezometers in the Quivira shale under the embankment indicate excess pore water pressure is still present from construction, however, it is dissipating. Piezometers in the Drum limestone in the valley indicate the Drum is open jointed and the cutoff trench is functioning with upstream devices response to pool changes. The Drum appears to be much tighter in the abutments than in the valleys, with pore water pressure build up during construction and little or no dissipation. Piezometer data agrees with observations made during construction, the Drum was weathered and upon jointed in the cutoff trench across the valley and

tightly jointed and relatively impermeable in the abutments. The Westerville limestone which underlies the Quivira shale also appears to be relatively impervious showing pore water pressure buildup during construction with slow dissipation. All of the piezometers in the embankment are located in the impervious zone, and they generally show a continued dissipation of construction pore pressure with the highest pressures in the bottom of the cutoff trench. Piezometer data is presented on Plates 193 through 260. Details of observation devices are shown on Plate 153.

7-03. Inclinometers. Eleven inclinometers are installed in the embankment to provide a means of measuring horizontal movements at differenet depths within the foundation and embankment. The locations of these devices are shown on Plate 153 with individual plots of movement on Plates 261 through 271. Inclinometer data shows movement up to 3 inches with most of it occurring during the first year. Generally readings are fluctuating indicating movement has stopped.

7-04. Foundation Settlement Plates. There are four foundation settlement plates located in the foundation overburden. Actual settlement agrees with the predicted settlement of 1.5 feet. Plates 193 through 196 show settlement data with the maximum total settlement 1.43 feet and the rate of settlement decreasing. Most of the settlement occurred during construction.

7-05. Alinement Monuments. Four lines of alinement monuments provide horizontal and vertical movement measurements. Alinement data is presented on Plates 156 through 192. Alinement monument lines A, B, and C indicate a decreasing rate of settlement. The settlement is predominately in the closure area on lines A, B, C. Line D is submerged. The maximum total vertical movement is 0.251 feet of settlement on line A. The largest total horizontal movement is 2.63 centimeters.

7-06. Crest Settlement Monuments. Nine crest settlement monuments indicate uniform settlement. The maximum settlement is 0.135 feet in the closure area. The centerline profile surveyed at 100-foot intervals shows close agreement with the crest settlement monuments indicating uniform settlement.

PHOTOGRAPHS

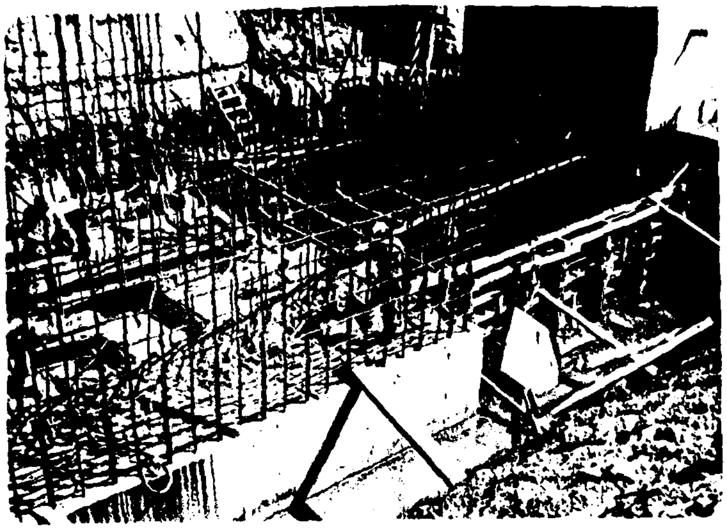
PHOTOGRAPHS

1. Right Abutment Cutoff Trench.

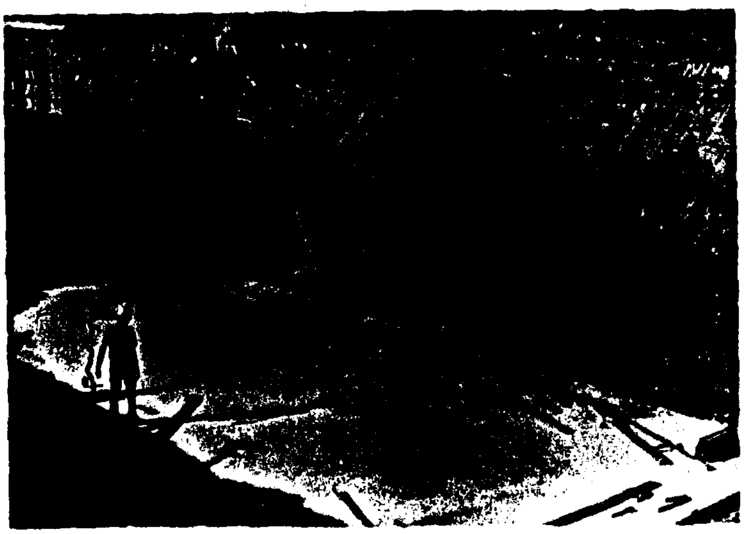
2. Station 116+50. Downstream Slope of Cutoff Trench.

3. Cutting Box Sample From Quivira Shale.

4. Sand Cone Density Test in Pervious Fill.



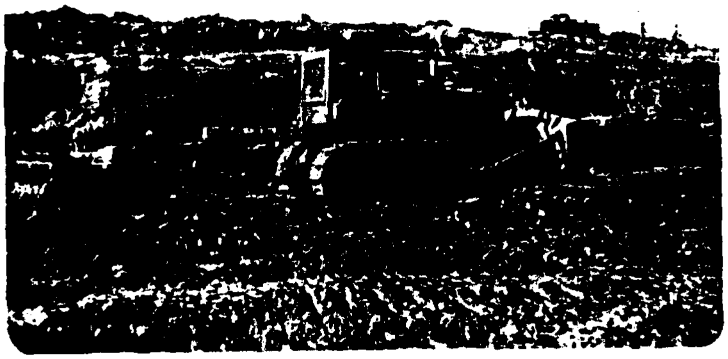
5. Placing Reinforcement for Conduit.



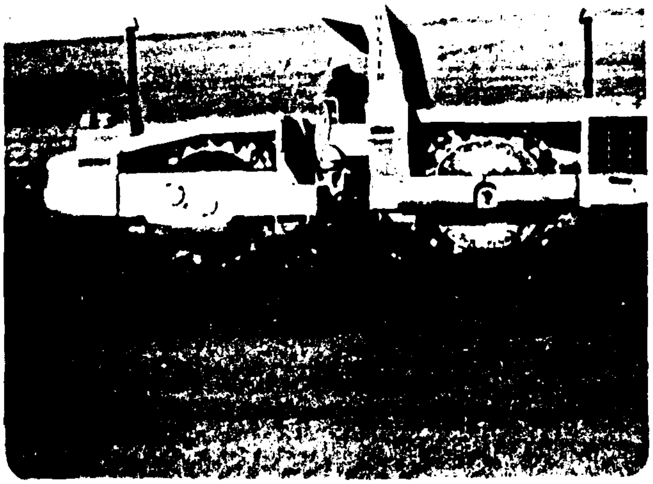
6. Constructing Conduit.

7. Mobile Belt Loader Used for Excavating Borrow Material.

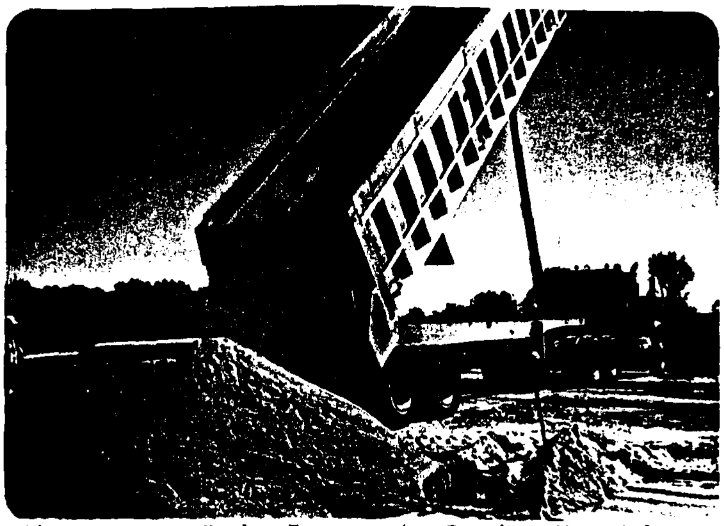
8. Bottom-Dump Haulers.



9. Bulldozer and Disk Used in Scarification

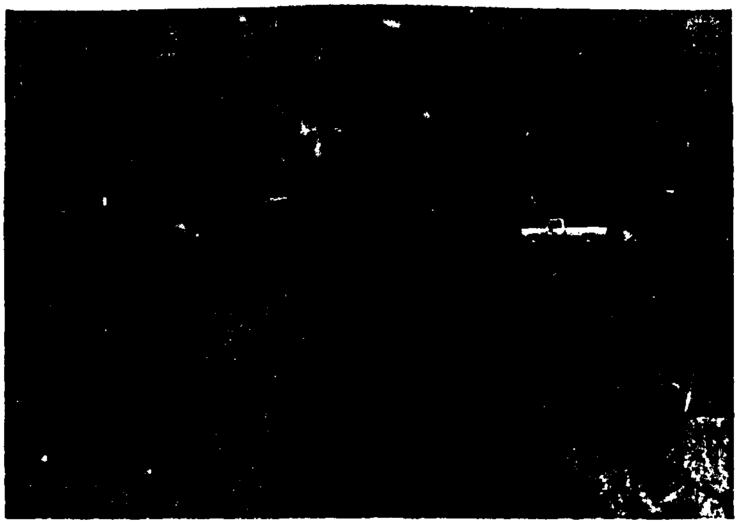


10. Self-Propelled Sheepsfoot Roller.



11. Rear-Dump Hauler Transporting Pervious Material.

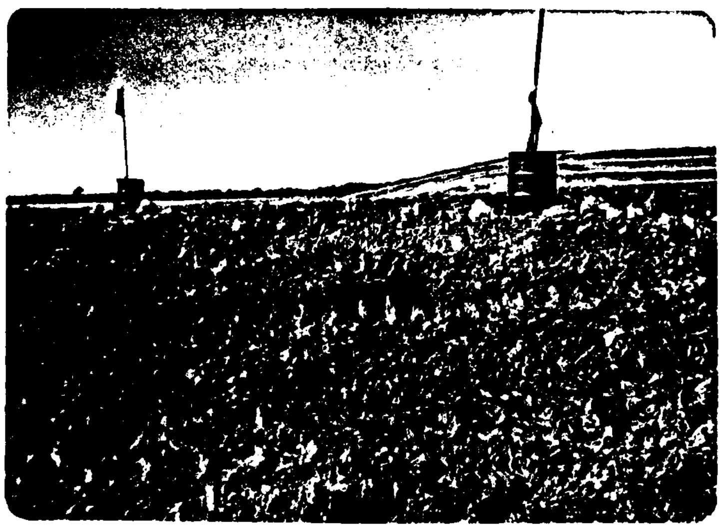
12. Vibratory Roller Compacting Pervious Fill.



13. Spreading Pervious Blanket.

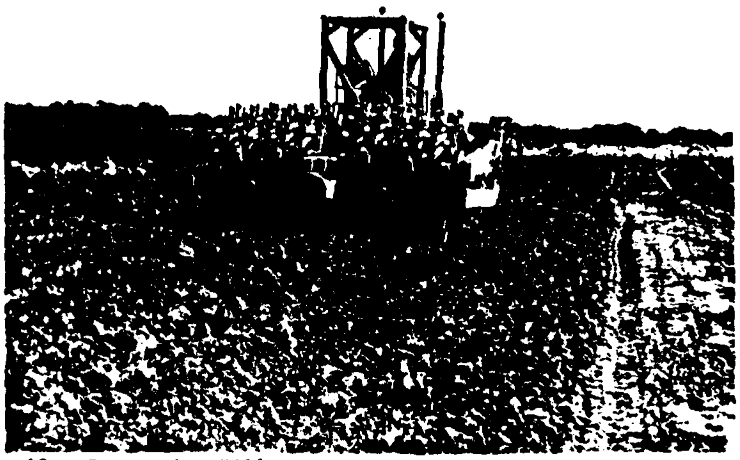
14. Watering Pervious Material.

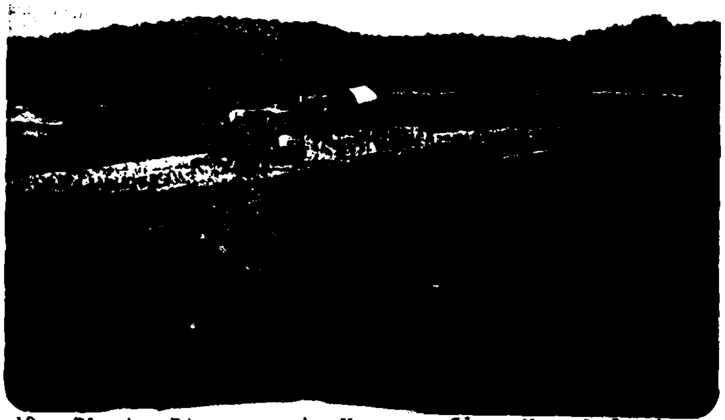
15. Compacting Pervious Fill.



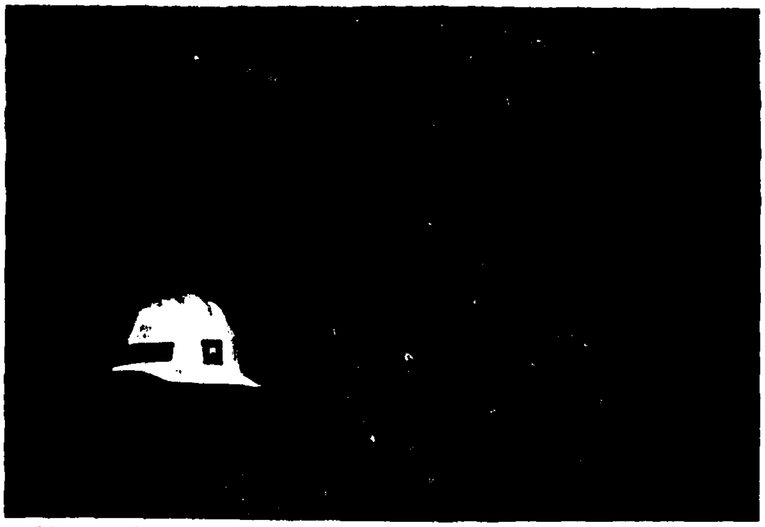
16. Protection for Instrumentation During Construction.
(Foundation Settlement Devise on Left and Piezometer on Right).


17. Grading Embankment Fill.

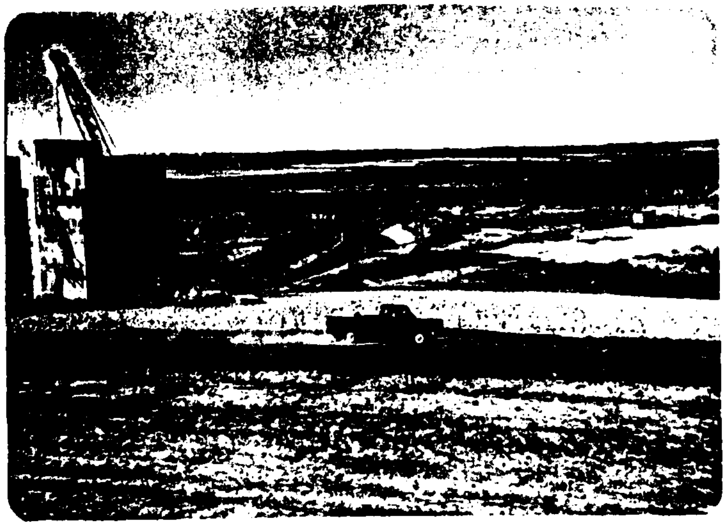

18. Compacting Fill.



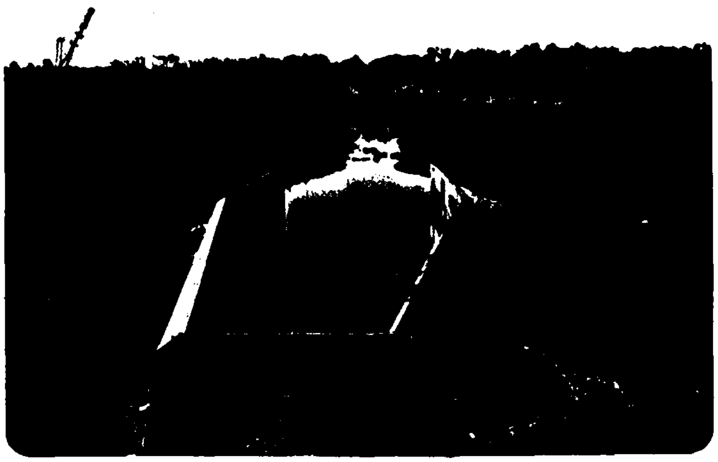
19. Placing Riprap on the Upstream Slope Near Left Abutment.



20. Twelve Inch Riprap in Place.



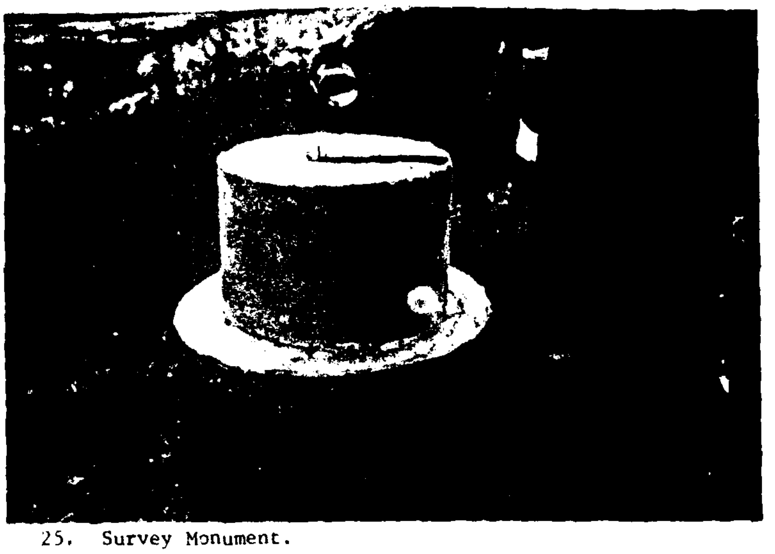
21. Intake Tower.



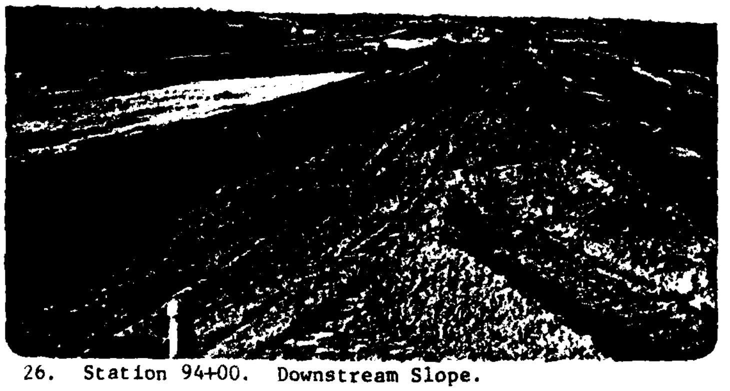
22. Stilling Basin.

23. Placing Limestone and Shale on Upstream Slope of the Cofferdam.

24. Fill Placement in the Closure Area.



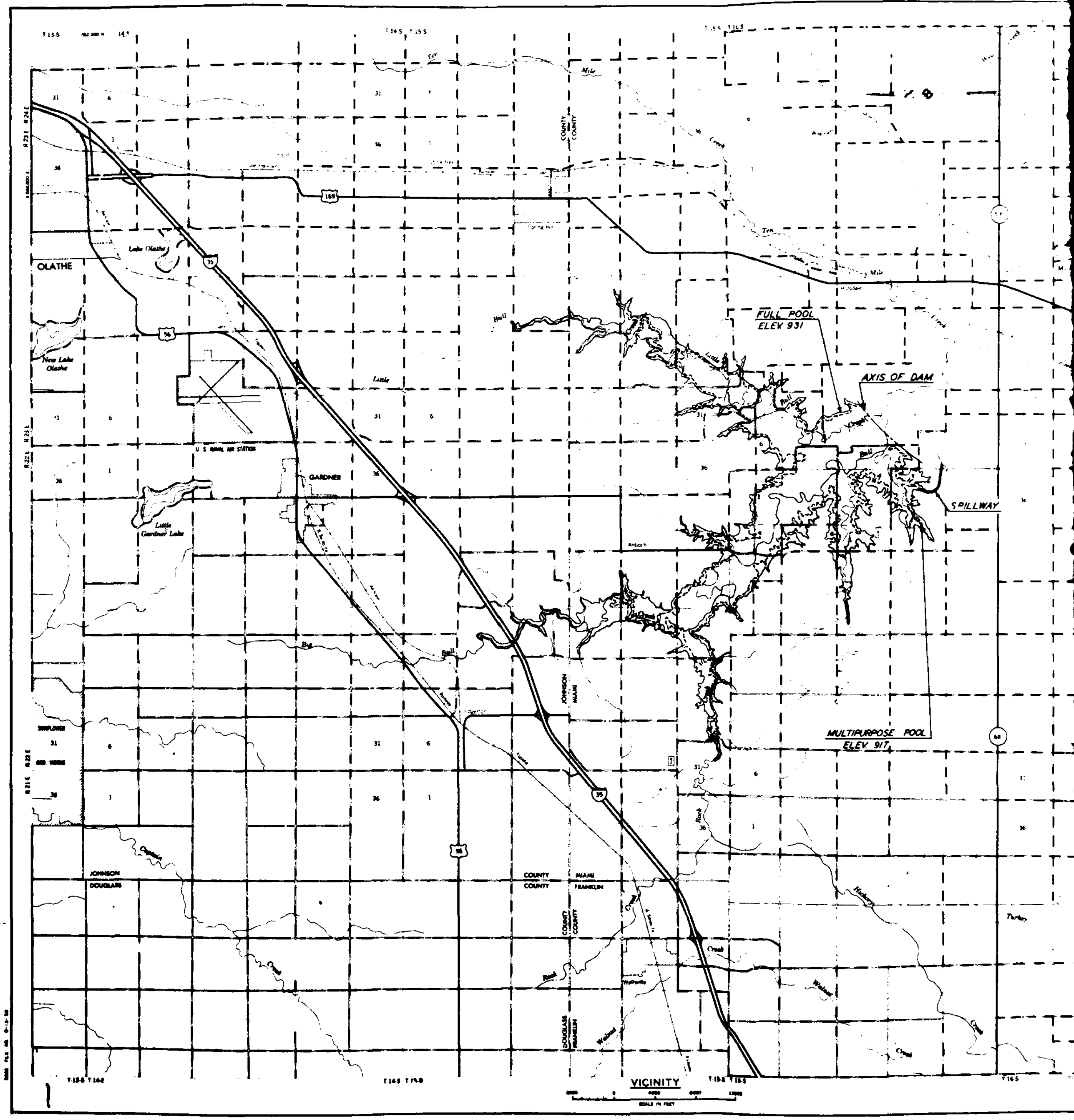
25. Survey Monument.



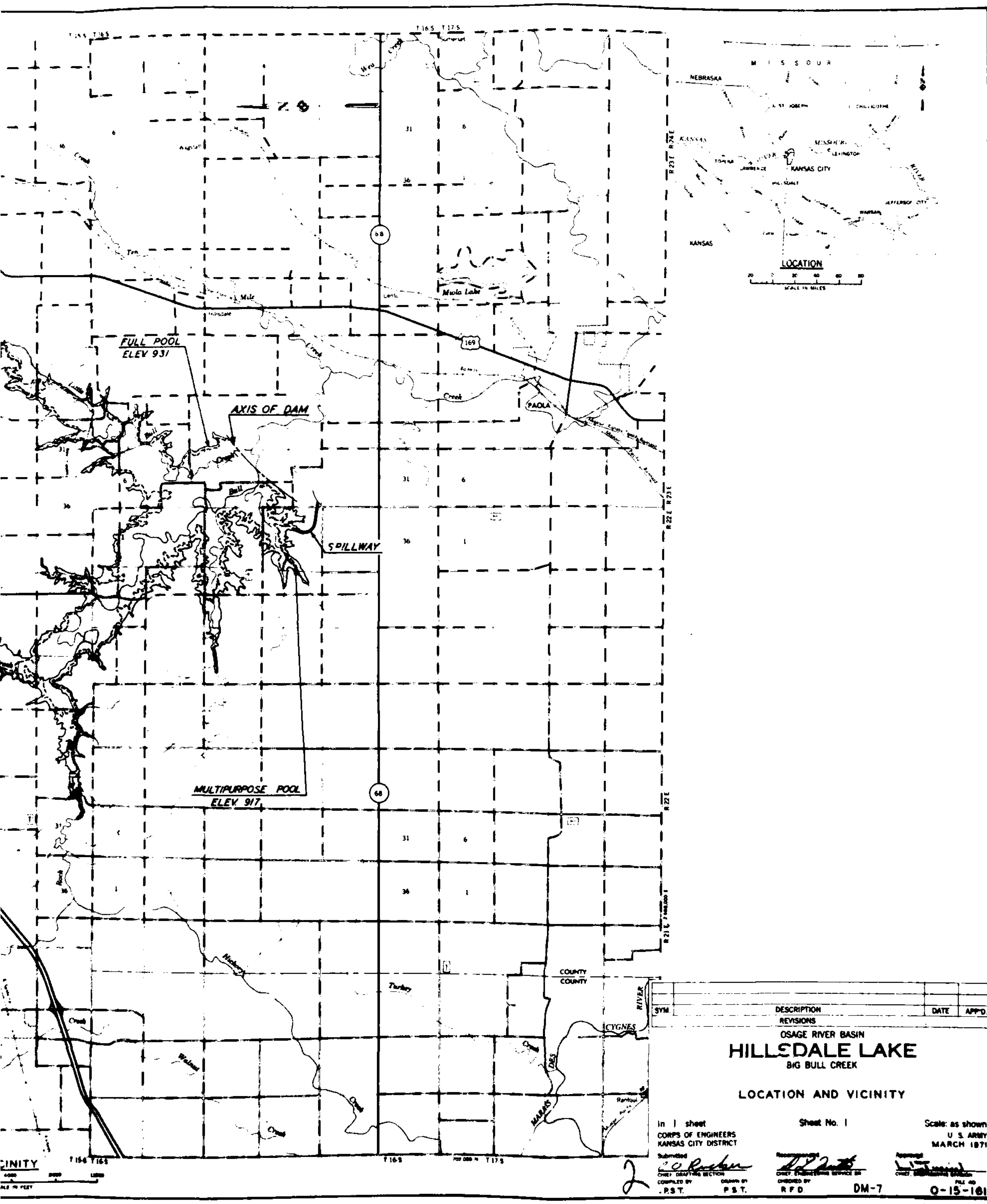
26. Station 94+00. Downstream Slope.

DRAWINGS

DRAWINGS



OLATHE
Lake Olathe
New Lake Olathe
Little Gardner Lake
GARDNER
U S NAVAL AIR STATION
FULL POOL
ELEV 931
AXIS OF DAM
SPILLWAY
MULTIPURPOSE POOL
ELEV 917
JOHNSON
DOUGLASS
COUNTY
COUNTY
MIAMI
FRANKLIN
VICINITY
SCALE IN FEET



SYM.	DESCRIPTION	DATE	APP'D.
	REVISIONS		

OSAGE RIVER BASIN

HILLSDALE LAKE

BIG BULL CREEK

LOCATION AND VICINITY

In 1 sheet — Sheet No. 1 — Scale: as shown

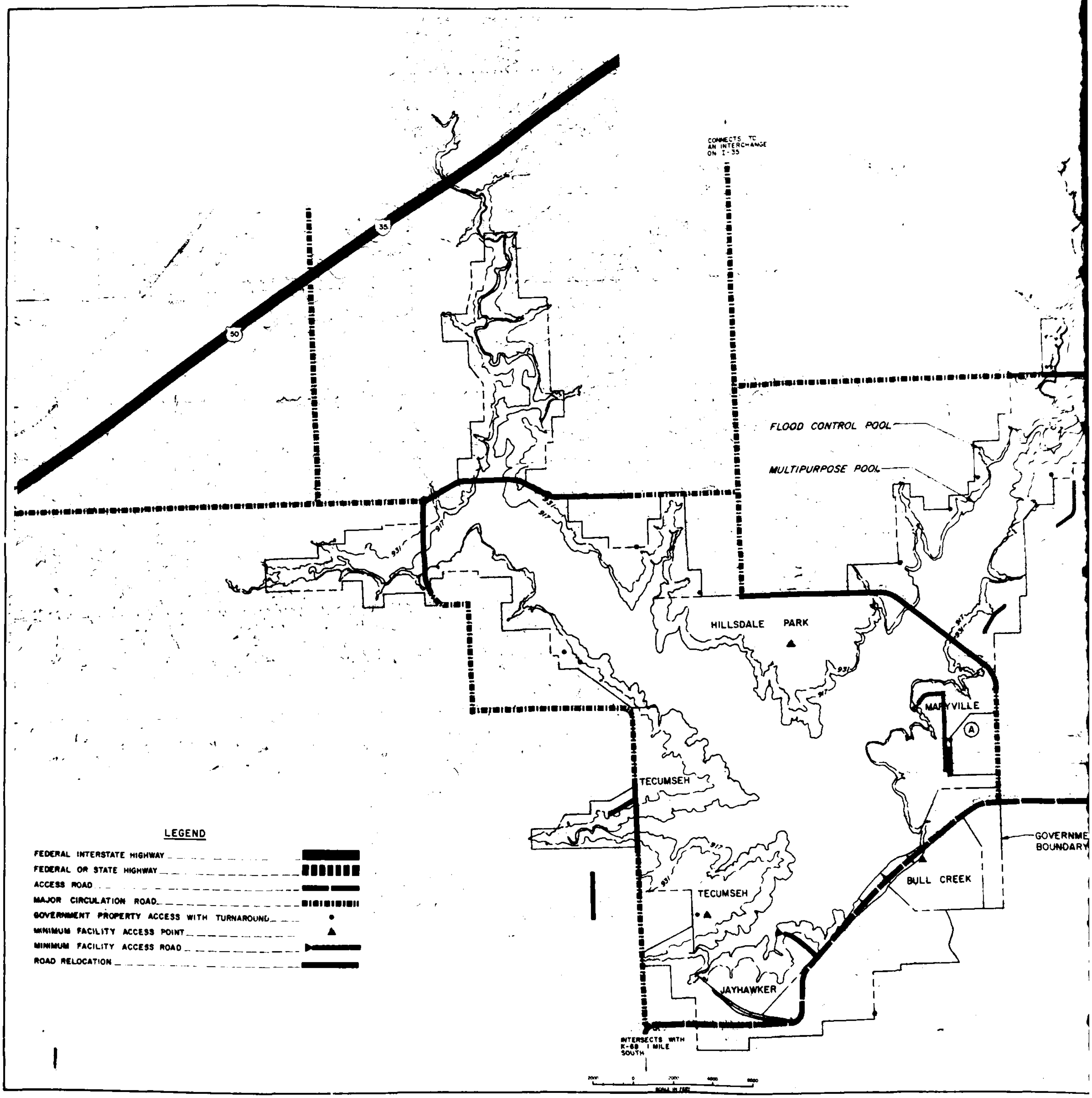
CORPS OF ENGINEERS
KANSAS CITY DISTRICT

U. S. ARMY
MARCH 1971

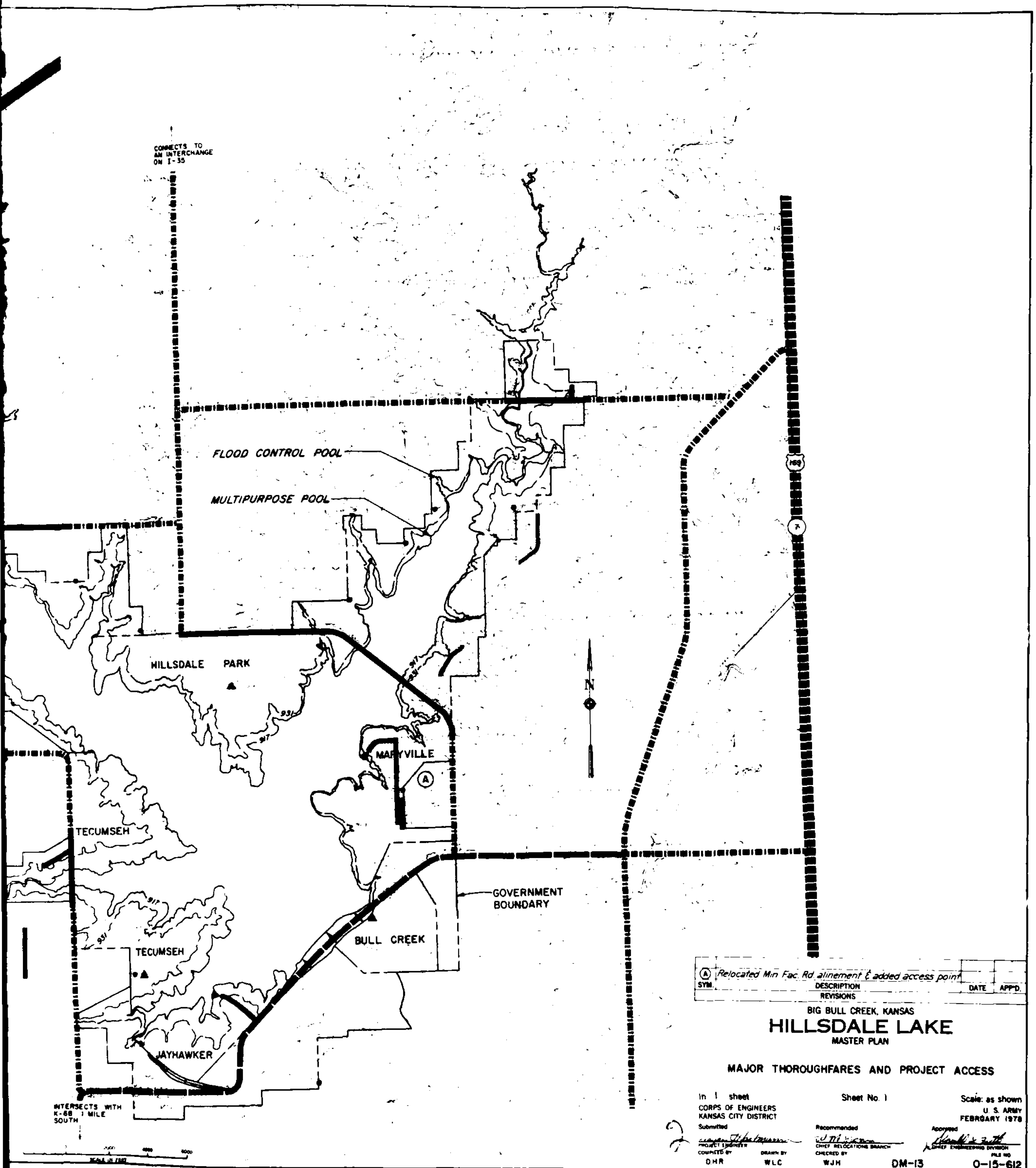
Submitted: CHIEF, DRAFTING SECTION — Recommended: CHIEF, ENGINEERING SERVICE BR. — Approved: CHIEF, ENGINEERING DIVISION

COMPILED BY .P.S.T. — DRAWN BY P.S.T. — CHECKED BY R.F.D. — DM-7 — FILE NO. O-15-161

PLATE NO 1

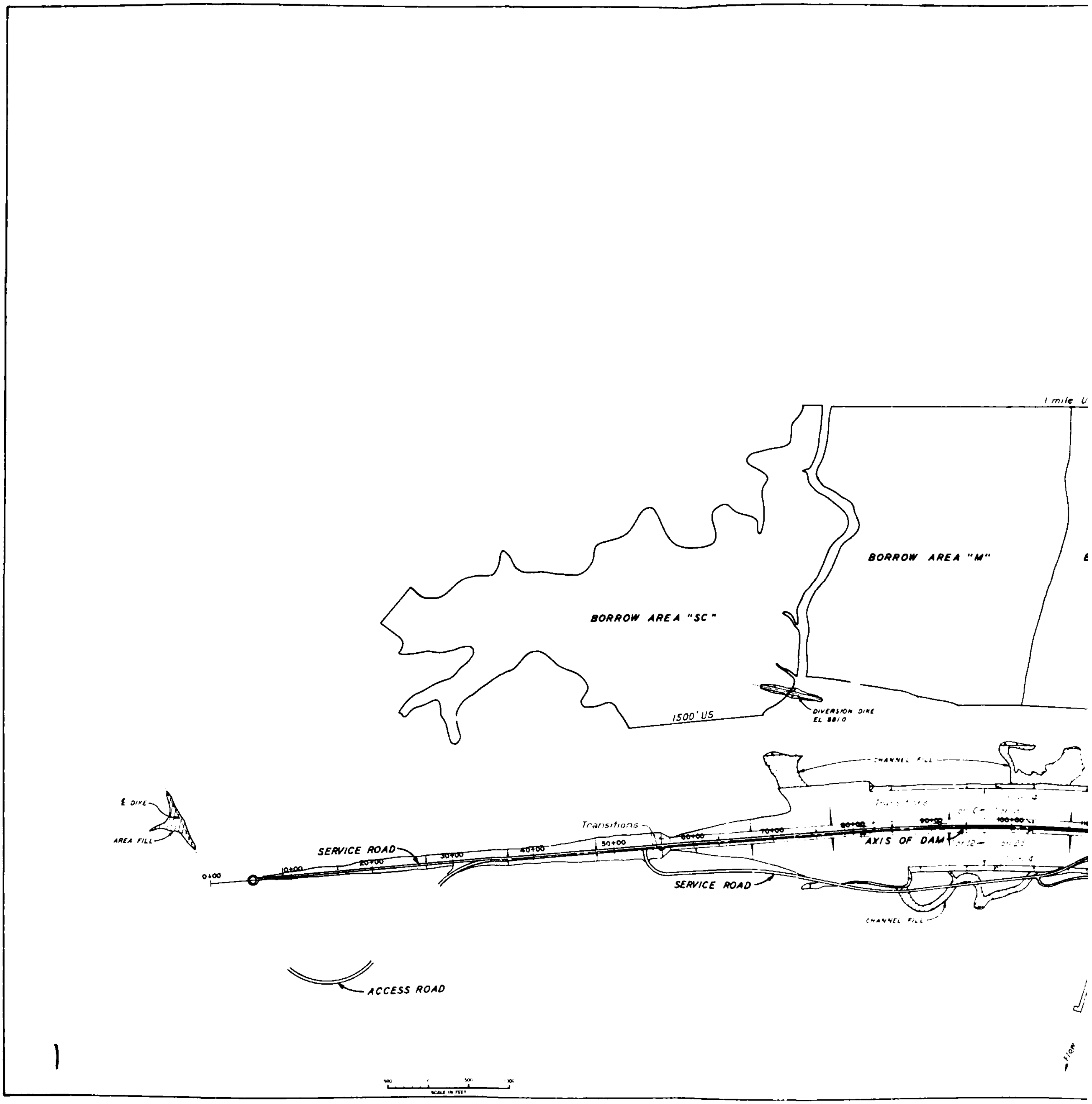


CONNECTS TO
AN INTERCHANGE
ON I-35
35
50
FLOOD CONTROL POOL
MULTIPURPOSE POOL
HILLSDALE PARK
MARYVILLE
A
TECUMSEH
TECUMSEH
BULL CREEK
JAYHAWKER
GOVERNME
BOUNDARY
INTERSECTS WITH
K-68 1 MILE
SOUTH
LEGEND
FEDERAL INTERSTATE HIGHWAY
FEDERAL OR STATE HIGHWAY
ACCESS ROAD
MAJOR CIRCULATION ROAD
GOVERNMENT PROPERTY ACCESS WITH TURNAROUND
MINIMUM FACILITY ACCESS POINT
MINIMUM FACILITY ACCESS ROAD
ROAD RELOCATION

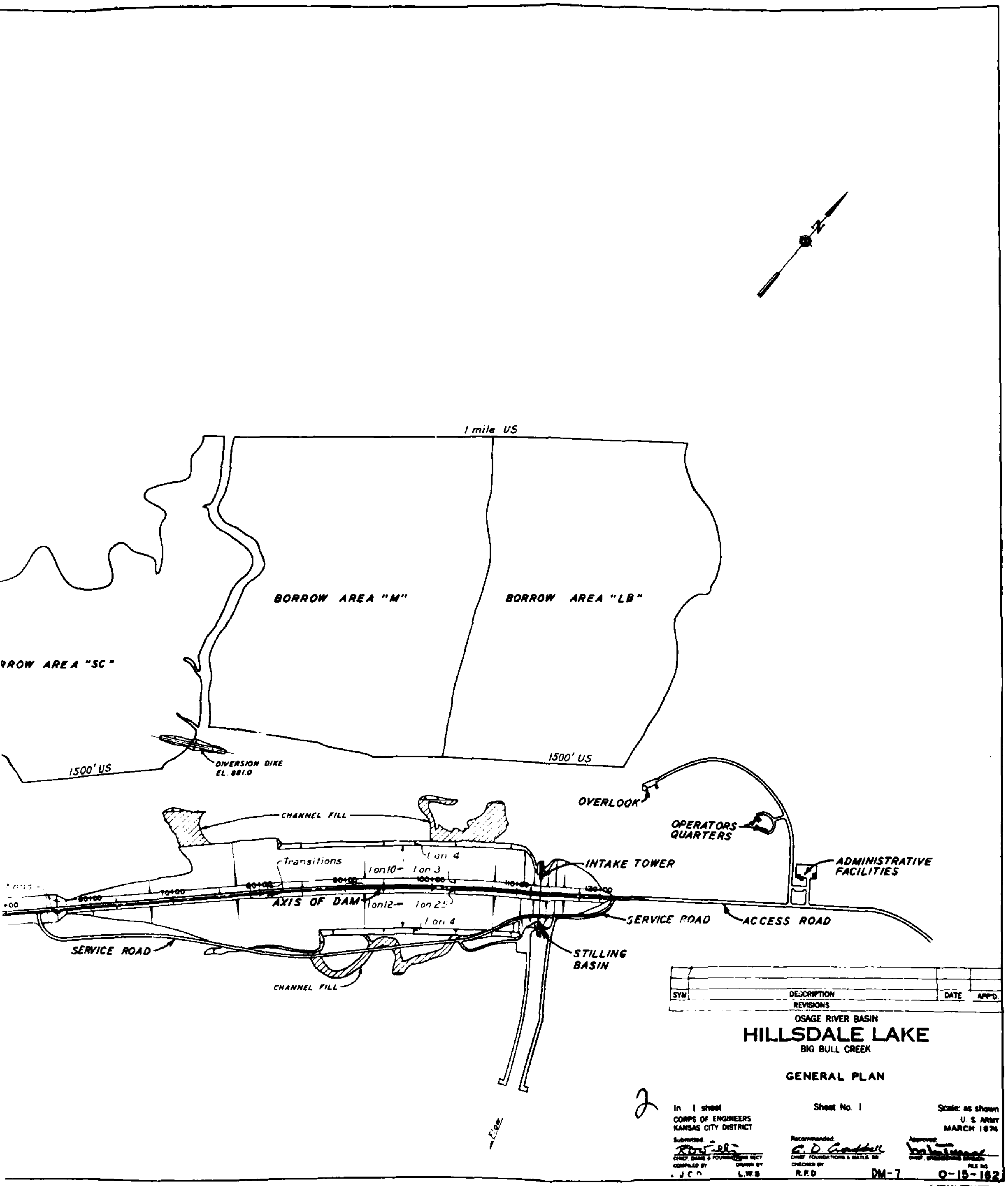


CONNECTS TO AN INTERCHANGE ON I-35
FLOOD CONTROL POOL
MULTIPURPOSE POOL
HILLSDALE PARK
MARYVILLE
TECUMSEH
TECUMSEH
GOVERNMENT BOUNDARY
BULL CREEK
JAYHAWKER
INTERSECTS WITH K-68 1 MILE SOUTH
N
Ⓐ Relocated Min Fac. Rd. alinement & added access point
SYM. DESCRIPTION DATE APP'D.
REVISIONS
BIG BULL CREEK, KANSAS
HILLSDALE LAKE
MASTER PLAN
MAJOR THOROUGHFARES AND PROJECT ACCESS
In 1 sheet
Sheet No. 1
Scale: as shown
CORPS OF ENGINEERS KANSAS CITY DISTRICT
U. S. ARMY FEBRUARY 1978
Submitted
Recommended
Approved
PROJECT ENGINEER
CHIEF RELOCATIONS BRANCH
CHIEF ENGINEERING DIVISION
COMPUTED BY DHR
DRAWN BY WLC
CHECKED BY WJH
DM-13
FILE NO. 0-15-612

PLATE NO. 2

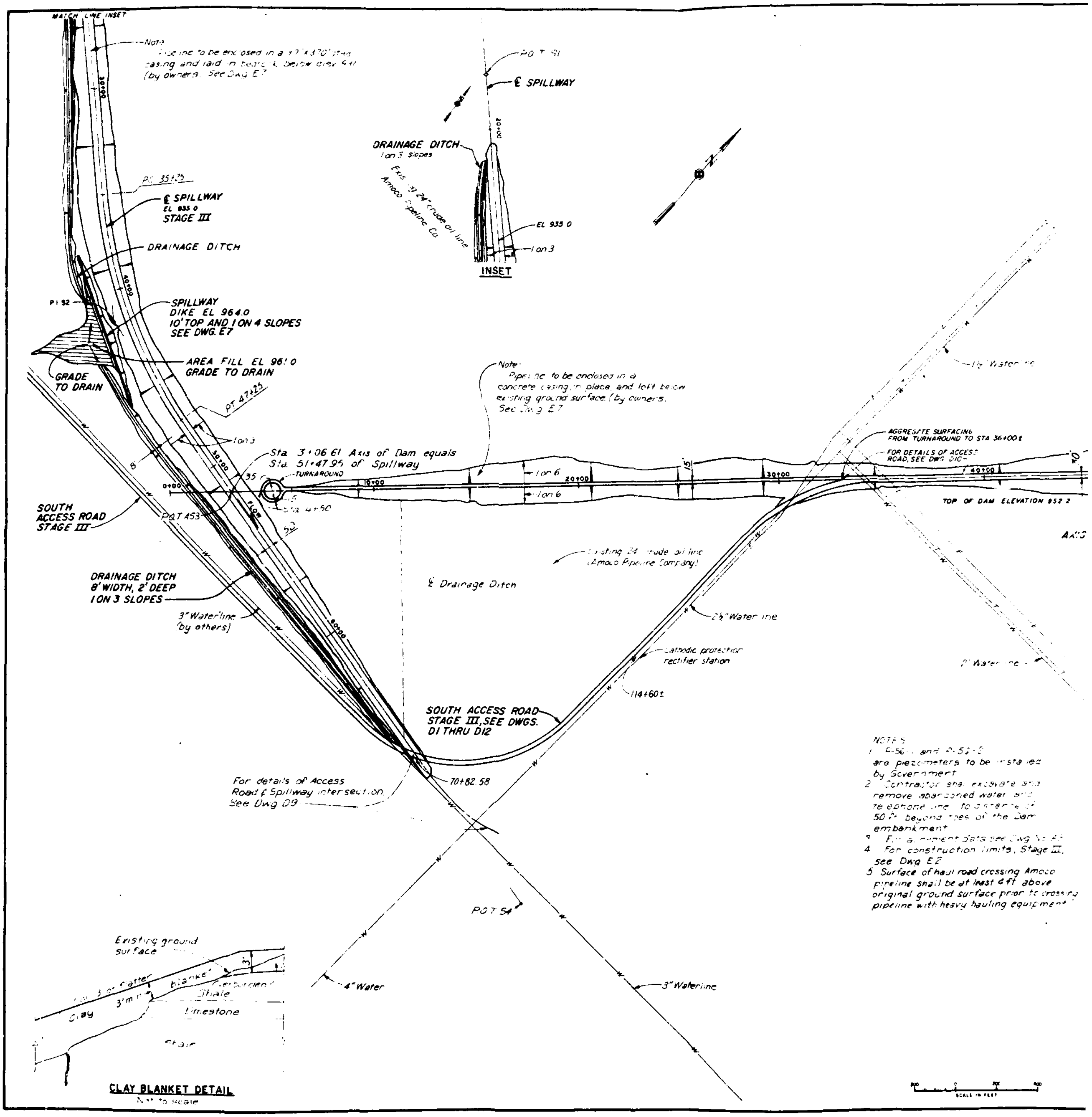


BORROW AREA "M"
BORROW AREA "SC"
1500' US
DIVERSION DIKE
CHANNEL FILL
℄ DIKE
AREA FILL
Transitions
SERVICE ROAD
AXIS OF DAM
SERVICE ROAD
CHANNEL FILL
ACCESS ROAD
0+00
10+00
20+00
30+00
40+00
50+00
60+00
70+00
80+00
90+00
100+00
SCALE IN FEET

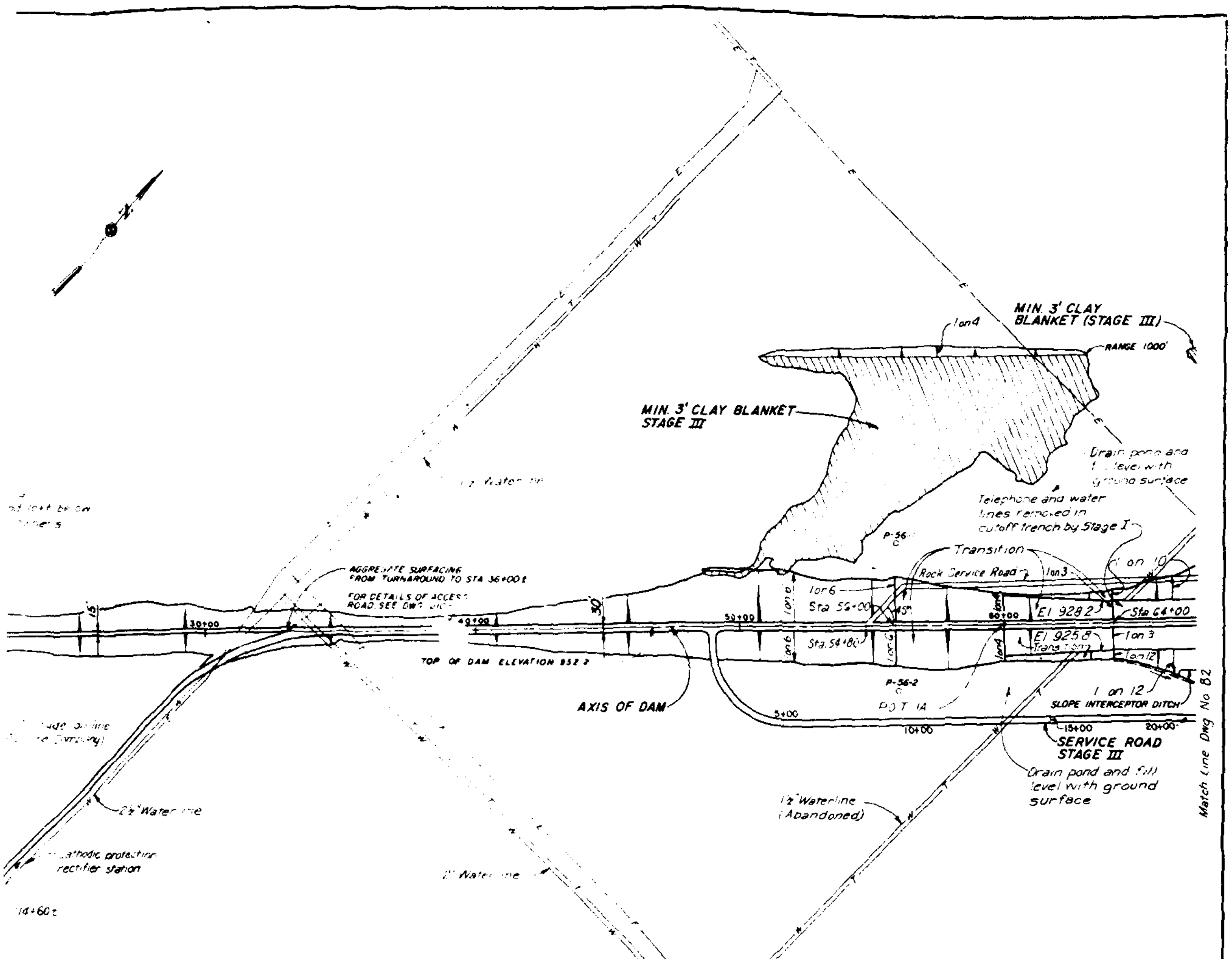


1 mile US
BORROW AREA "M"
BORROW AREA "LB"
RROW AREA "SC"
1500' US
1500' US
DIVERSION DIKE EL. 881.0
CHANNEL FILL
OVERLOOK
OPERATORS QUARTERS
ADMINISTRATIVE FACILITIES
INTAKE TOWER
Transitions
1 on 4
1 on 10
1 on 3
AXIS OF DAM
1 on 12
1 on 25
1 on 4
SERVICE ROAD
ACCESS ROAD
SERVICE ROAD
STILLING BASIN
CHANNEL FILL
Flow
SYM
DESCRIPTION
DATE
APP'D.
REVISIONS
OSAGE RIVER BASIN
HILLSDALE LAKE
BIG BULL CREEK
GENERAL PLAN
In 1 sheet
Sheet No. 1
Scale: as shown
CORPS OF ENGINEERS
KANSAS CITY DISTRICT
U. S. ARMY
MARCH 1974
Submitted
Recommended
Approved
J.C.R.
L.W.S.
R.P.D.
DM-7
O-15-162

PLATE NO. 3



MATCH LINE INSET
€ SPILLWAY
DRAINAGE DITCH
1 on 3 Slopes
Exist. 24" crude oil line
Amoco Pipeline Co.
EL 935 0
1 on 3
INSET
PI 351+25
€ SPILLWAY
EL 935 0
STAGE III
DRAINAGE DITCH
SPILLWAY
DIKE EL 964.0
10' TOP AND 1 ON 4 SLOPES
SEE DWG. E7
AREA FILL EL 961.0
GRADE TO DRAIN
GRADE
TO DRAIN
PT 47+25
1 on 3
Note:
Pipeline to be enclosed in a
concrete casing in place, and left below
existing ground surface (by owners.
See Dwg. E7
Sta. 3+06.61 Axis of Dam equals
Sta. 51+47.95 of Spillway
TURNAROUND
1 on 6
1 on 6
10+00
20+00
30+00
40+00
AGGREGATE SURFACING
FROM TURNAROUND TO STA 36+00±
FOR DETAILS OF ACCESS
ROAD, SEE DWG. D10
TOP OF DAM ELEVATION 952.2
SOUTH
ACCESS ROAD
STAGE III
PI&T 453
Existing 24" crude oil line
(Amoco Pipeline Company)
€ Drainage Ditch
DRAINAGE DITCH
8' WIDTH, 2' DEEP
1 ON 3 SLOPES
3" Waterline
(by others)
2½" Water line
Cathodic protection
rectifier station
114+60±
2" Water line
SOUTH ACCESS ROAD
STAGE III, SEE DWGS.
D1 THRU D12
70+82.58
For details of Access
Road & Spillway intersection,
See Dwg. D9
4" Water
3" Waterline
Existing ground
surface
Blanket
Shale
Limestone
Clay
Shale
CLAY BLANKET DETAIL
Not to scale
NOTES
are piezometers to be installed
by Government.
4. For construction limits, Stage III,
see Dwg. E2.
5. Surface of haul road crossing Amoco
pipeline shall be at least 4 ft above
original ground surface prior to crossing
pipeline with heavy hauling equipment.
SCALE IN FEET



NOTES:

1. P-56-1 and P-56-2 are piezometers to be installed by Government
2. Contractor shall excavate and remove abandoned water and telephone line to distance of 50 ft beyond toes of the Dam embankment.
3. For alignment data, see Dwg No A5
4. For construction limits, Stage III, see Dwg E2
5. Surface of haul road crossing Amoco pipeline shall be at least 4 ft above original ground surface prior to crossing pipeline with heavy hauling equipment

LEGEND

EXISTING POWERLINE	——E——
EXISTING TELEPHONE LINE	——T——
EXISTING WATERLINE	——W——
EXISTING PIPELINE	

RECORD DRAWING

JULY 1982

CONTRACT NO. DACW41 78-C-0113

SYM.	DESCRIPTION	DATE	APP'D.
	Revised for "As Built" conditions		

REVISIONS

BIG BULL CREEK, KANSAS

HILLSDALE LAKE

STAGE III CONSTRUCTION

2

EMBANKMENT PLAN

Dwg No B1

CORPS OF ENGINEERS
KANSAS CITY DISTRICT

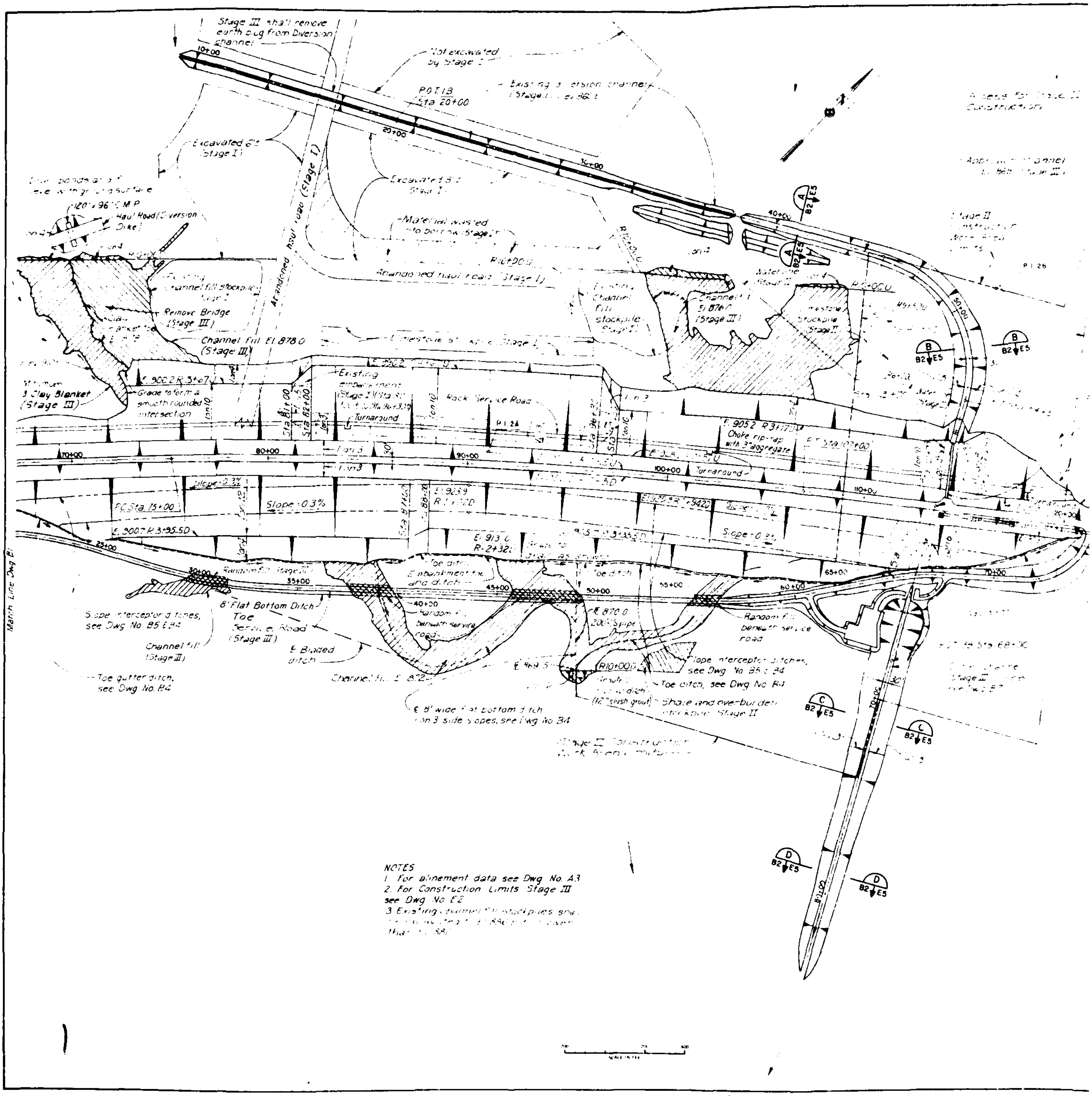
Scale: as shown
U. S. ARMY
APRIL 1978

Submitted: CHIEF, DAMS & FOUNDATIONS SECT.
Recommended: CHIEF, FOUNDATIONS & MATLS BR.
Approved: CHIEF, ENGINEERING DIVISION

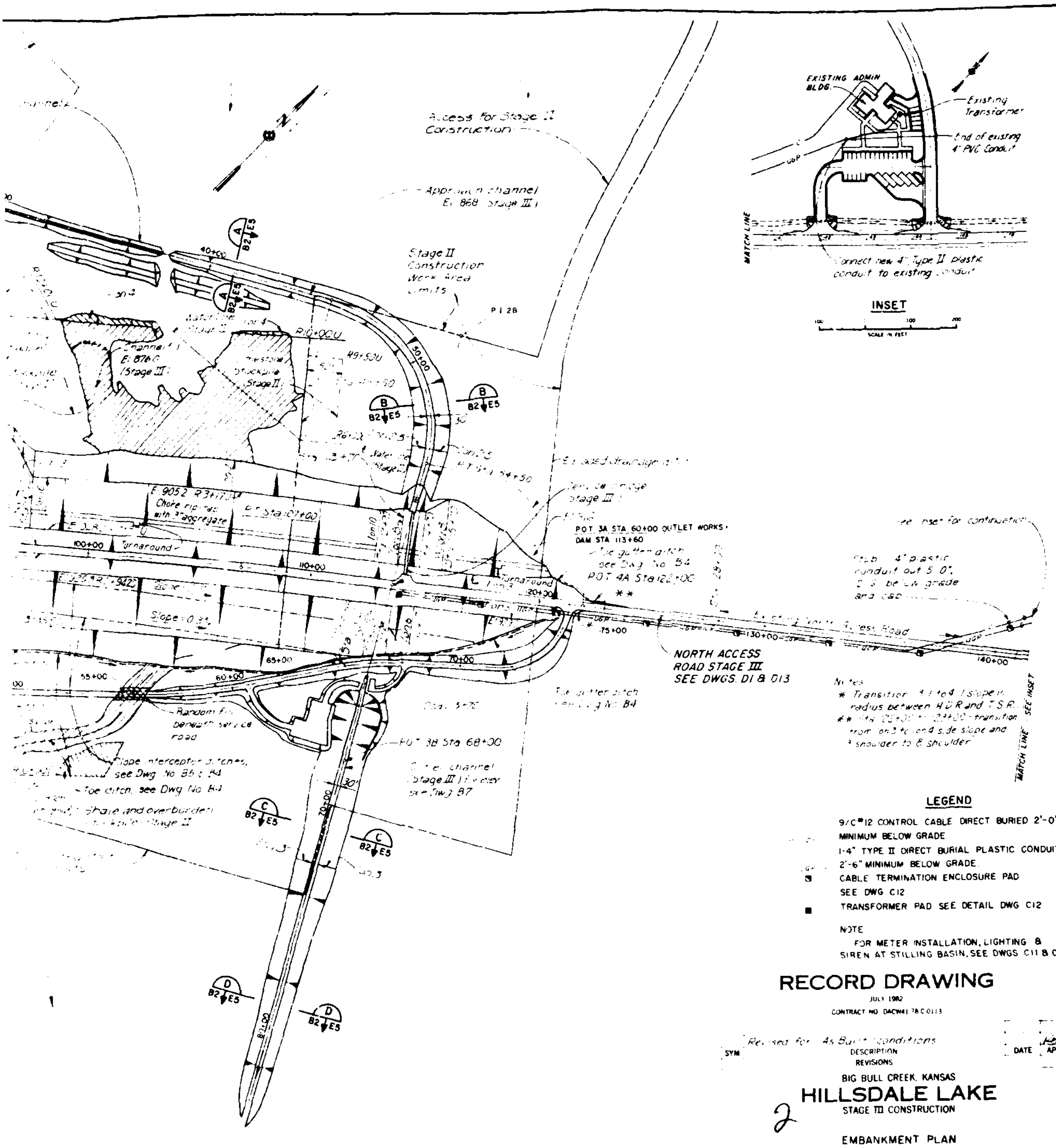
COMPILED BY RGF
DRAWN BY RLD
CHECKED BY RGF

FILE NO. 0-15-884

PLATE NO. 4



Stage III shall remove earth plug from Diversion channel
10+00
Not excavated by Stage I
P.O.T. 1B Sta 20+00
20+00
30+00
40+00
Excavated 6' (Stage I)
Excavated 6' Stage I
Material wasted into borrow Stage II
Abandoned haul road (Stage I)
Abandoned haul road (Stage I)
120" x 96" C.M.P.
Haul Road (Diversion Dike)
Existing channel fill stockpile Stage I
Remove Bridge (Stage III)
Channel fill El. 878.0 (Stage III)
Minimum 3' Clay Blanket (Stage III)
Grade to form a smooth rounded intersection
Existing embankment
Turnaround
Rock Service Road
Existing Channel Fill stockpile Stage I
Channel fill El. 876.0 (Stage III)
Limestone stockpile (Stage II)
Stage II Construction Work Area Limits
Choke rip-rap with 3" aggregate
70+00
80+00
90+00
100+00
110+00
Turnaround
Slope 0.3%
Slope 0.3%
P.C. Sta. 75+00
Slope 0.3%
E. 900.7 R. 3+95.5D
E. 913.0 R-2+32
25+00
30+00
35+00
45+00
50+00
55+00
60+00
65+00
70+00
Random fill Stage III
Toe ditch
Embankment toe and ditch
Toe ditch
Slope interceptor ditches, see Dwg. No. B5 & B4
8' Flat Bottom Ditch Toe Service Road (Stage III)
Random fill beneath service road
El. 870.0
Random fill beneath service road
Channel fill (Stage III)
℄ Graded ditch
Toe gutter ditch, see Dwg. No. B4
Channel fill El. 872
R10+00
Slope interceptor ditches, see Dwg. No. B5 & B4
Toe ditch, see Dwg. No. B4
(12" slush grout)
Shale and overburden stockpile Stage II
℄ 8' wide flat bottom ditch on 3 side slopes, see Dwg. No. B4
Match Line Dwg. B1
A B2 E5
B B2 E5
C B2 E5
D B2 E5
P.I. 2A
P.I. 2B
NOTES
1. For alinement data see Dwg. No. A3
2. For Construction Limits Stage III see Dwg. No. E2
3. Existing channel fill stockpiles shall ...



Notes
* Transition 4:1 to 4:1 slope in radius between H.D.R and T.S.R.
** Sta 126+00 to 131+00 - transition from 3 to 1 end side slope and 3' shoulder to 8' shoulder

LEGEND

9/C #12 CONTROL CABLE DIRECT BURIED 2'-0" MINIMUM BELOW GRADE
1-4" TYPE II DIRECT BURIAL PLASTIC CONDUIT 2'-6" MINIMUM BELOW GRADE
CABLE TERMINATION ENCLOSURE PAD SEE DWG C12
TRANSFORMER PAD SEE DETAIL DWG C12

NOTE
FOR METER INSTALLATION, LIGHTING & SIREN AT STILLING BASIN, SEE DWGS C11 & C12

RECORD DRAWING

JULY 1982
CONTRACT NO DACW41 78 C 0113

SYM	DESCRIPTION	DATE	APP'D
	Revised for As Built conditions		

REVISIONS

BIG BULL CREEK, KANSAS

HILLSDALE LAKE

STAGE III CONSTRUCTION

2

EMBANKMENT PLAN

Dwg. No. B2
CORPS OF ENGINEERS
KANSAS CITY DISTRICT

Scale as shown
U. S. ARMY
APRIL 1978

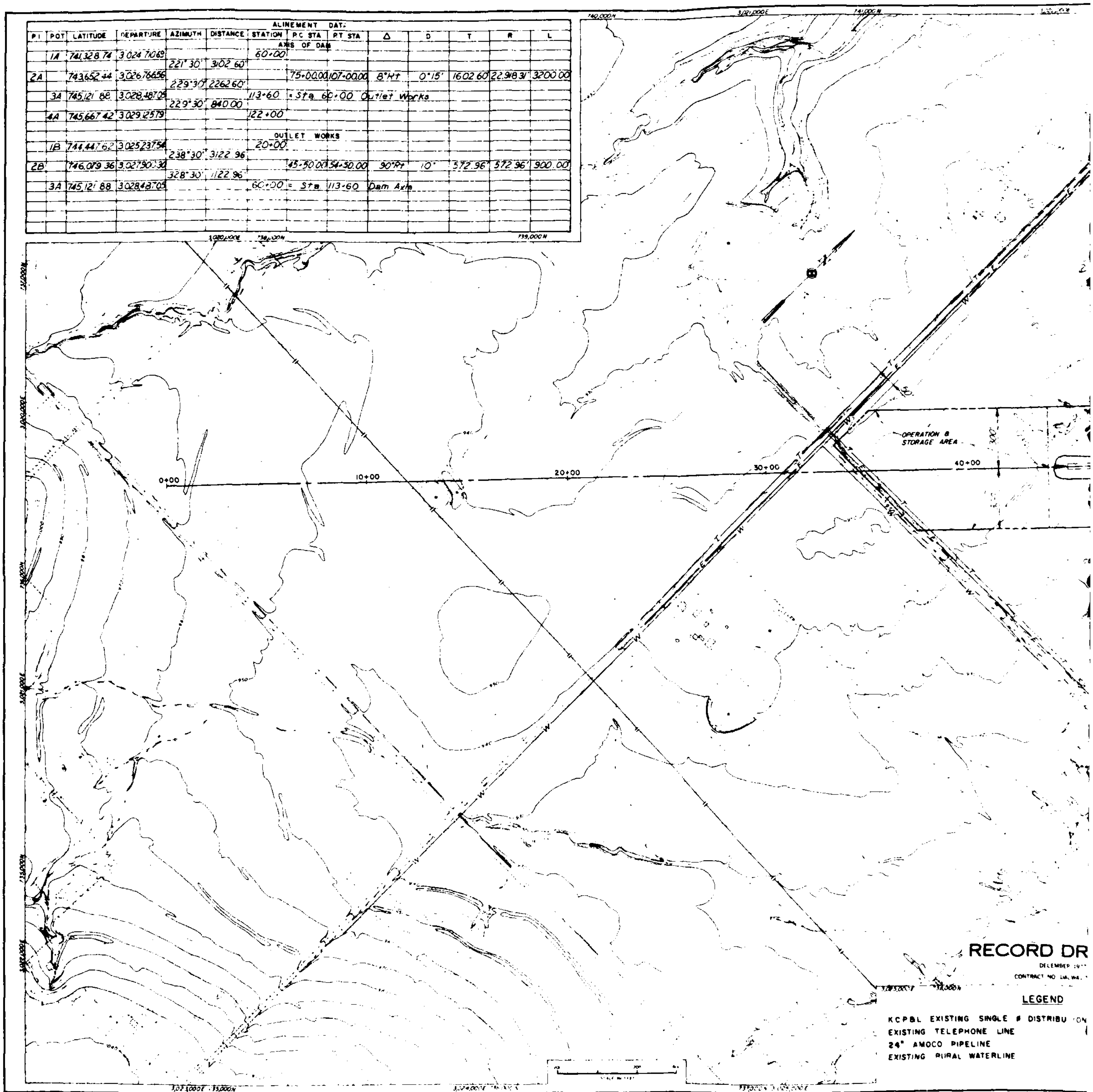
Submitted
Recommended
Approved

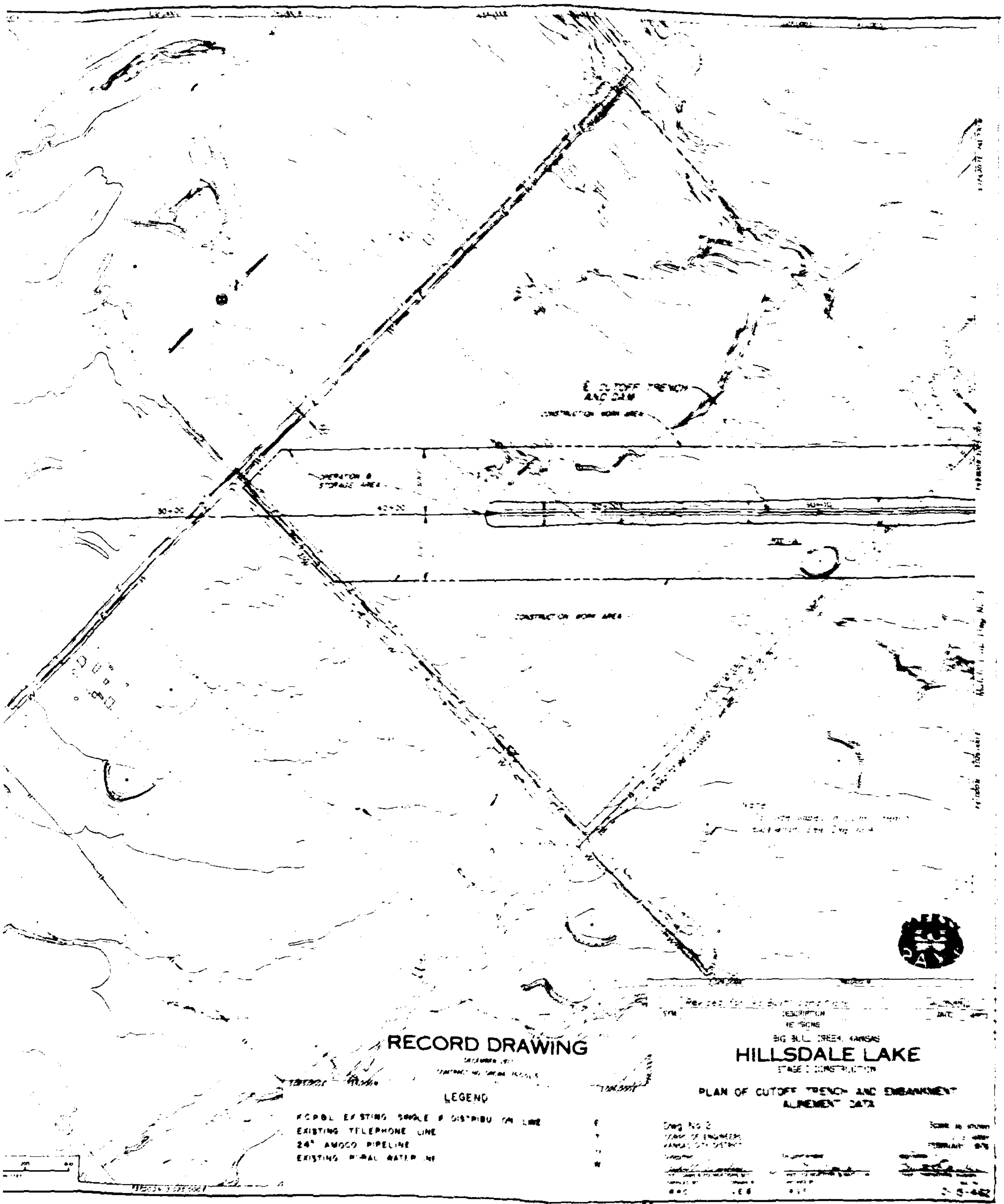
R G F
L G M - F C L
R G F

0-15-685

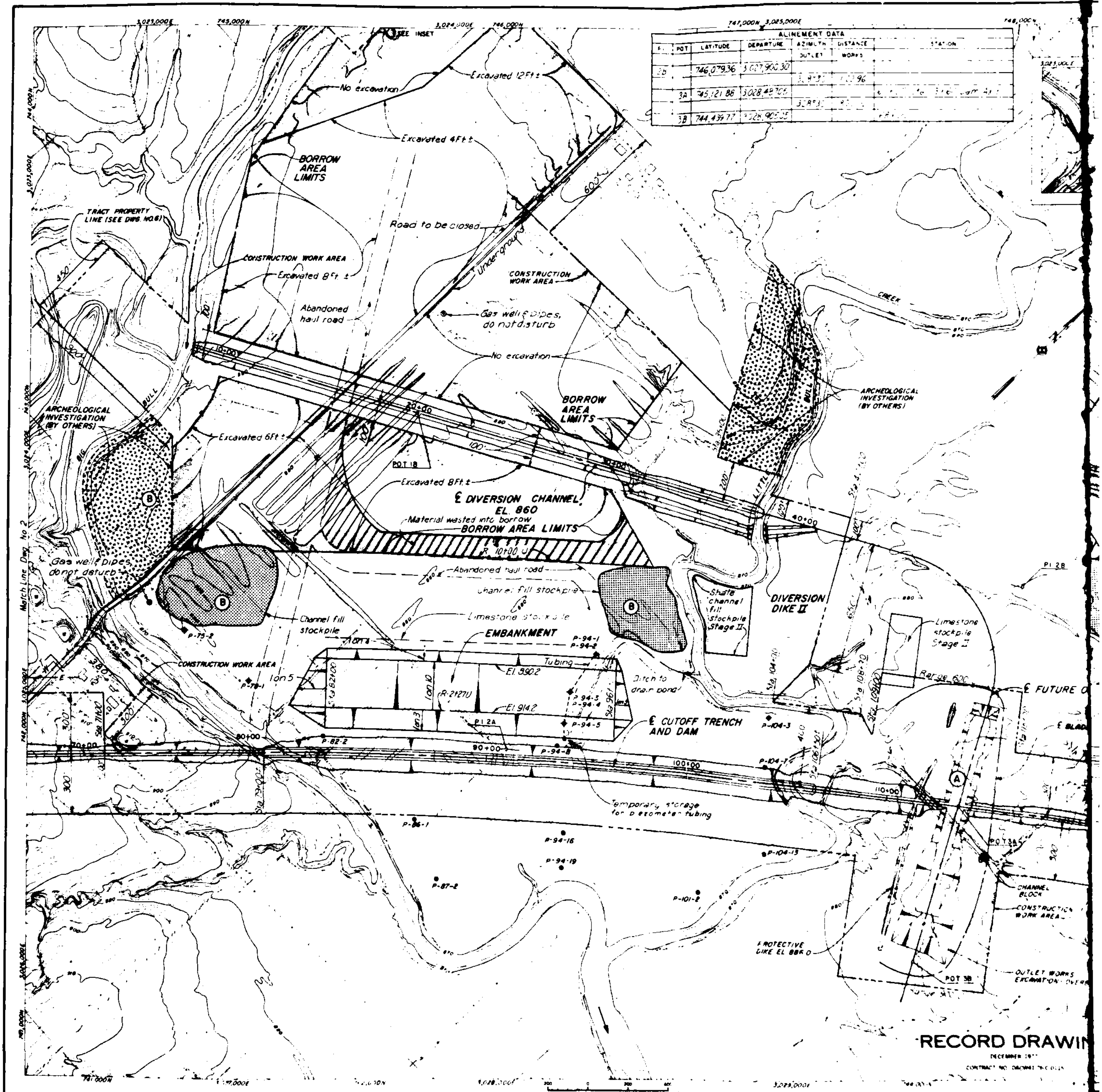
PLATE NO 5

						ALINEMENT DATA							
PI	POT	LATITUDE	DEPARTURE	AZIMUTH	DISTANCE	STATION	PC STA	PT STA	Δ	D	T	R	L
						AXIS OF DAM							
	1A	741,328.74	3,024,710.69			60+00							
				221°30'	3102.60'								
2A		743,652.44	3,026,766.56				75+00.00	107+00.00	8°Rt	0°15'	1602.60'	22,918.31'	3200.00
				229°30'	2262.60'								
	3A	745,121.88	3,028,487.05			113+60	= Sta 60+00 Outlet Works						
				229°30'	840.00								
	4A	745,667.42	3,029,125.79			122+00							
						OUTLET WORKS							
	1B	744,447.62	3,025,237.54			20+00							
				238°30'	3122.96								
2B		746,079.36	3,027,900.30				45+50.00	54+50.00	90°Rt	10°	572.96'	572.96'	900.00
				328°30'	1122.96'								
	3A	745,121.88	3,028,487.05			60+00	= Sta 113-60 Dam Axis						





CONSTRUCTION WORK AREA
OPERATION & STORAGE AREA
30+00
40+00
CONSTRUCTION WORK AREA
RECORD DRAWING
LEGEND
EXISTING TELEPHONE LINE
24" AMOCO PIPELINE
DESCRIPTION
BIG BULL CREEK, KANSAS
HILLSDALE LAKE
PLAN OF CUTOFF TRENCH AND EMBANKMENT
Scale as shown



ALINEMENT DATA
LATITUDE
DEPARTURE
AZIMUTH
DISTANCE
STATION
OUTLET WORKS
2B 746,079.36 3,027,900.30
3A 745,121.86 3,028,457.05
3B 744,439.77
SEE INSET
No excavation
Excavated 12Ft ±
Excavated 4Ft ±
BORROW AREA LIMITS
TRACT PROPERTY LINE (SEE DWG NO.6)
Road to be closed
CONSTRUCTION WORK AREA
Excavated 8Ft ±
Underground
Abandoned haul road
Gas well pipes, do not disturb
No excavation
ARCHEOLOGICAL INVESTIGATION (BY OTHERS)
Excavated 6Ft ±
POT 1B
Excavated 8Ft ±
℄ DIVERSION CHANNEL, EL. 860
Material wasted into borrow
BORROW AREA LIMITS
Gas well pipes, do not disturb
Match Line Dwg No 2
Abandoned haul road
Channel fill stockpile
Limestone stockpile
Channel fill stockpile
EMBANKMENT
Shale channel fill stockpile Stage II
DIVERSION DIKE II
Limestone stockpile Stage II
CONSTRUCTION WORK AREA
Tubing
El 890.2
El 914.2
Ditch to drain pond
℄ CUTOFF TRENCH AND DAM
℄ FUTURE
CREEK
Temporary storage for piezometer tubing
CHANNEL BLOCK
CONSTRUCTION WORK AREA
PROTECTIVE DIKE EL 888.0
OUTLET WORKS EXCAVATION
POT 3A
POT 3B
10+00
20+00
40+00
80+00
90+00
100+00
110+00
P-94-1
P-94-2
P-94-5
P-94-8
P-94-16
P-94-19
P-104-3
P-104-13
P-101-2
P-87-2
P-82-2
P-75-2
P 12A
P 12B
SCALE IN FEET
RECORD DRAWIN

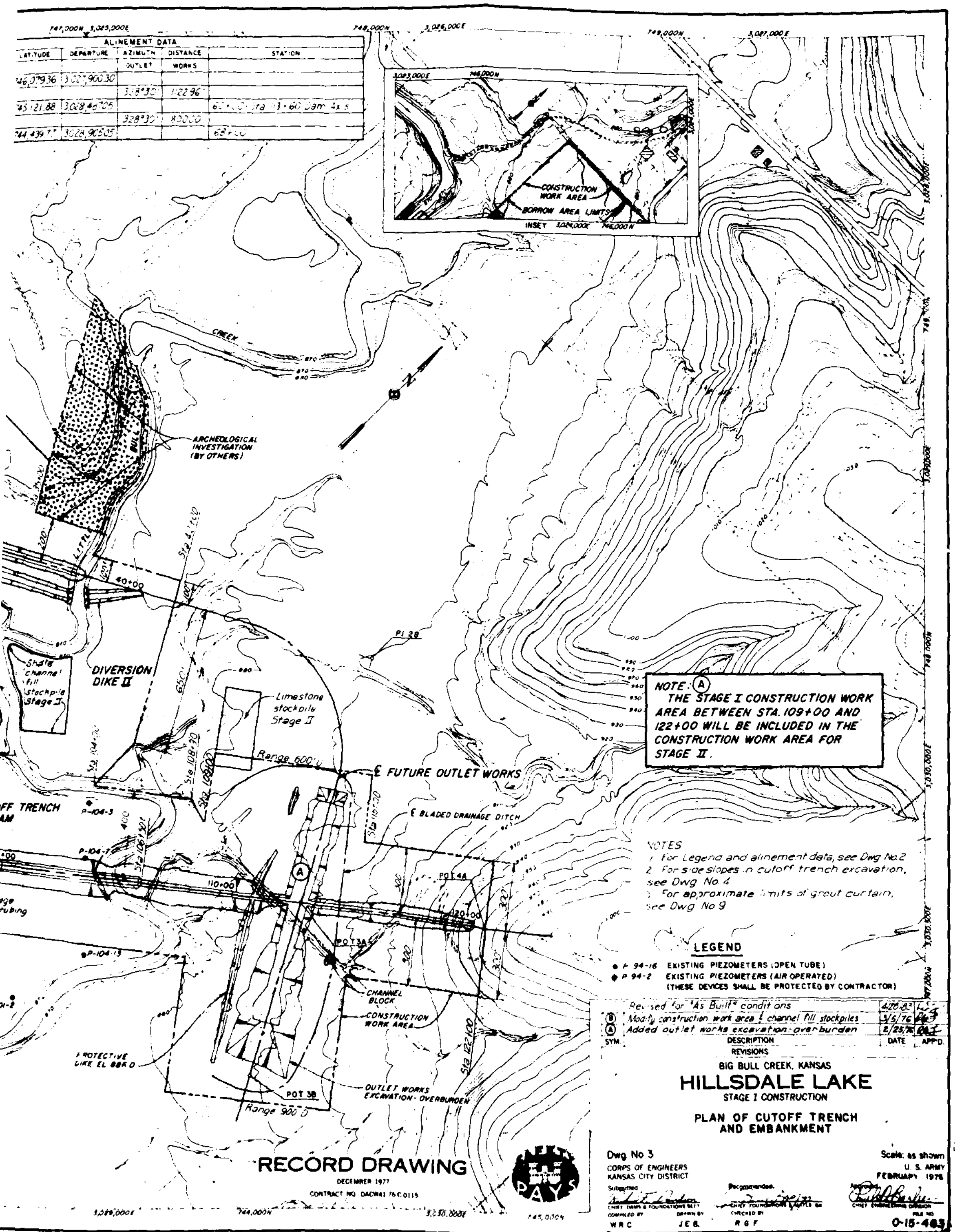
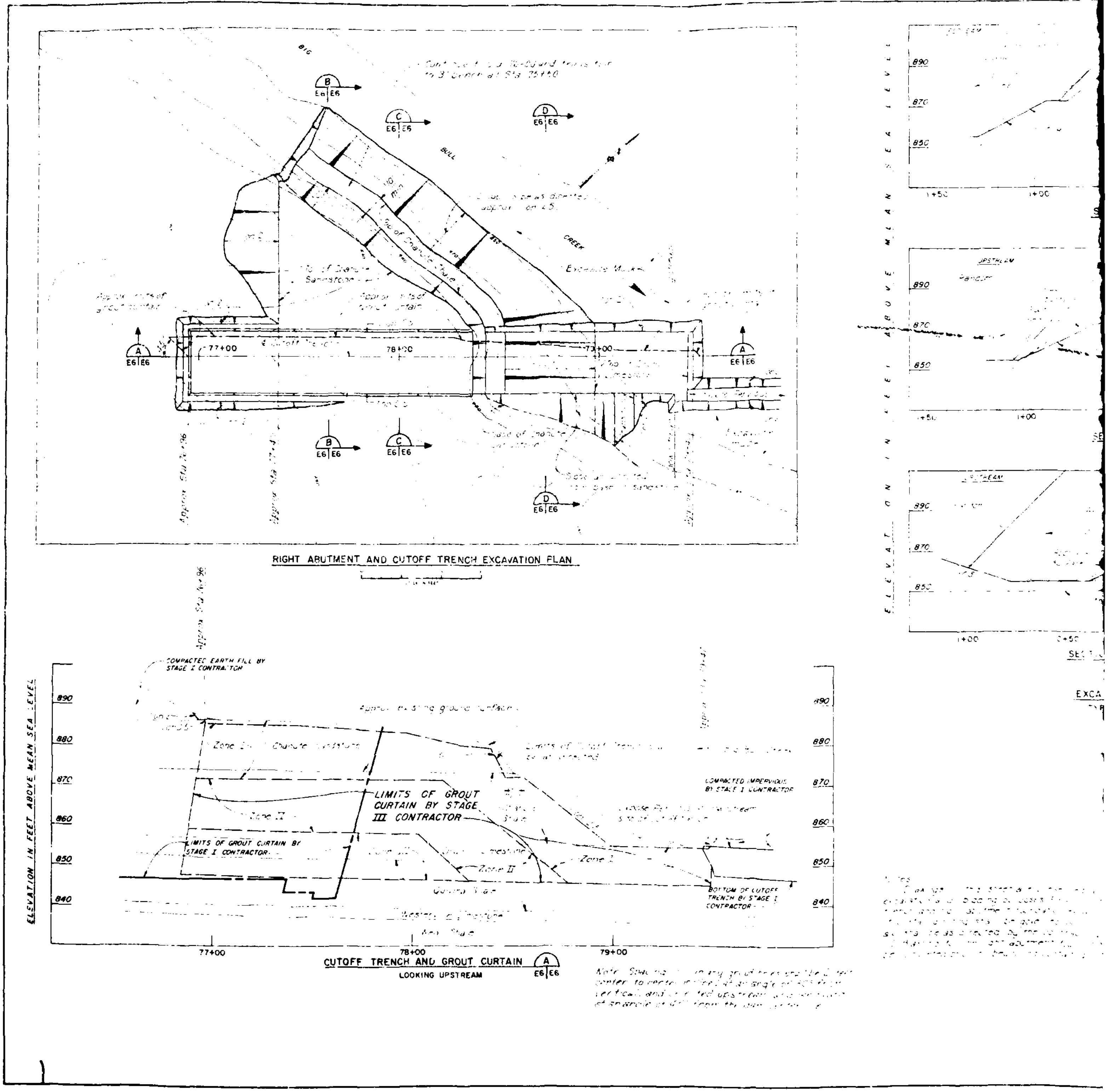
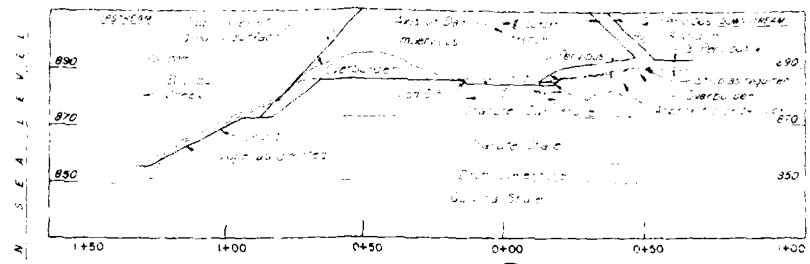

ALINEMENT DATA
LATITUDE DEPARTURE AZIMUTH DISTANCE STATION
OUTLET WORKS
746,027.36 3,027,900.30
328°30' 1122.96'
328°30' 830.00
CONSTRUCTION WORK AREA
BORROW AREA LIMITS
INSET
CREEK
ARCHEOLOGICAL INVESTIGATION (BY OTHERS)
DIVERSION DIKE II
Limestone stockpile Stage II
Range 600'
℄ FUTURE OUTLET WORKS
℄ BLADED DRAINAGE DITCH
PI 28
NOTE: (A) THE STAGE I CONSTRUCTION WORK AREA BETWEEN STA. 109+00 AND 122+00 WILL BE INCLUDED IN THE CONSTRUCTION WORK AREA FOR STAGE II.
NOTES
1. For Legend and alinement data, see Dwg No.2
2. For side slopes in cutoff trench excavation, see Dwg No 4
3. For approximate limits of grout curtain, see Dwg No 9
LEGEND
P 94-16 EXISTING PIEZOMETERS (OPEN TUBE)
P 94-2 EXISTING PIEZOMETERS (AIR OPERATED) (THESE DEVICES SHALL BE PROTECTED BY CONTRACTOR)
CHANNEL BLOCK
CONSTRUCTION WORK AREA
PROTECTIVE DIKE EL 880.0
OUTLET WORKS EXCAVATION - OVERBURDEN
Range 900.0
POT 3B
POT 4A
Revised for "As Built" conditions
(B) Modify construction work area & channel fill stockpiles 3/5/76
(A) Added outlet works excavation-overburden 2/25/76
SYM. DESCRIPTION DATE APP'D.
REVISIONS
BIG BULL CREEK, KANSAS
HILLSDALE LAKE
STAGE I CONSTRUCTION
PLAN OF CUTOFF TRENCH AND EMBANKMENT
Dwg No 3
CORPS OF ENGINEERS KANSAS CITY DISTRICT
Scale: as shown
U. S. ARMY
FEBRUARY 1976
COMPILED BY W R C
DRAWN BY J E B
CHECKED BY R G F
0-15-483
RECORD DRAWING
DECEMBER 1977
CONTRACT NO. DACW41 76 C 0115
SAFETY PAYS

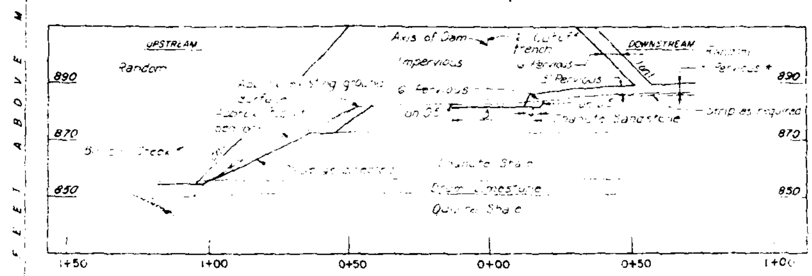
PLATE NO. 7



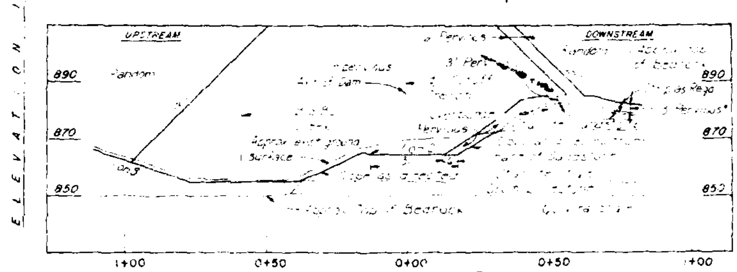
RIGHT ABUTMENT AND CUTOFF TRENCH EXCAVATION PLAN
BIG
BULL
CREEK
77+00
78+00
79+00
E6 E6
CUTOFF TRENCH AND GROUT CURTAIN
LOOKING UPSTREAM
ELEVATION IN FEET ABOVE MEAN SEA LEVEL
890
880
870
860
850
840
COMPACTED EARTH FILL BY STAGE I CONTRACTOR
LIMITS OF GROUT CURTAIN BY STAGE III CONTRACTOR
LIMITS OF GROUT CURTAIN BY STAGE I CONTRACTOR
COMPACTED IMPERVIOUS BY STAGE I CONTRACTOR
BOTTOM OF CUTOFF TRENCH BY STAGE I CONTRACTOR
Zone II
Zone III
Zone I
UPSTREAM
EXCA



SECTION - STA. 77+65 B E6|E6



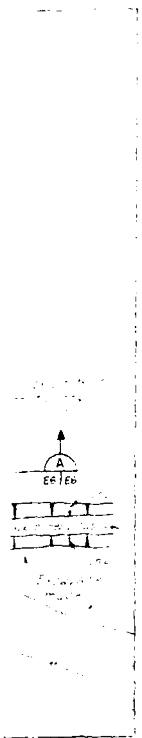
SECTION - STA. 78+00 C E6|E6

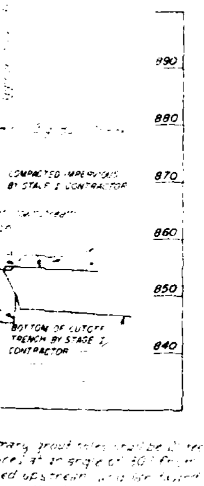


SECTION - STA. 78+73 D E6|E6

EXCAVATION AND EMBANKMENT DETAILS

TYPICAL FROM STA 77+00± TO 79+50±





RECORD DRAWING

SYM DESCRIPTION DATE APP'D

REVISIONS

BIG BULL CREEK, KANSAS

HILLSDALE LAKE

STAGE III CONSTRUCTION

RIGHT ABUTMENT AND CUTOFF TRENCH EXCAVATION PLAN AND SECTIONS AND GROUT CURTAIN PROFILE

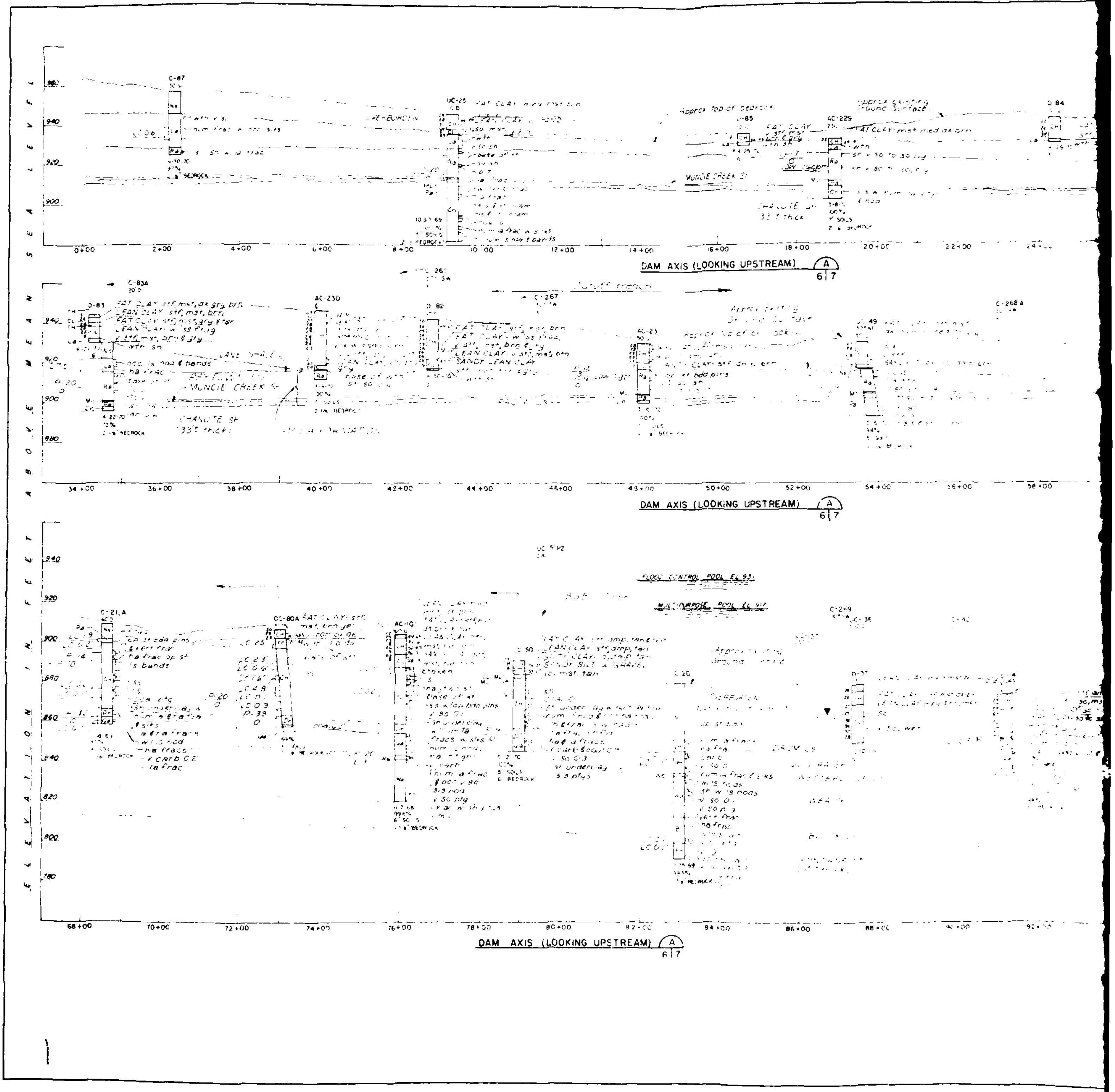
Dwg. No. E6
CORPS OF ENGINEERS
KANSAS CITY DISTRICT

Scale: as shown
U. S. ARMY
APRIL 1978

M.L.S. J.P.M. M.L.S./R.G.F.

0-15-731

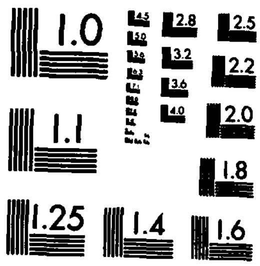
PLATE NO. 8



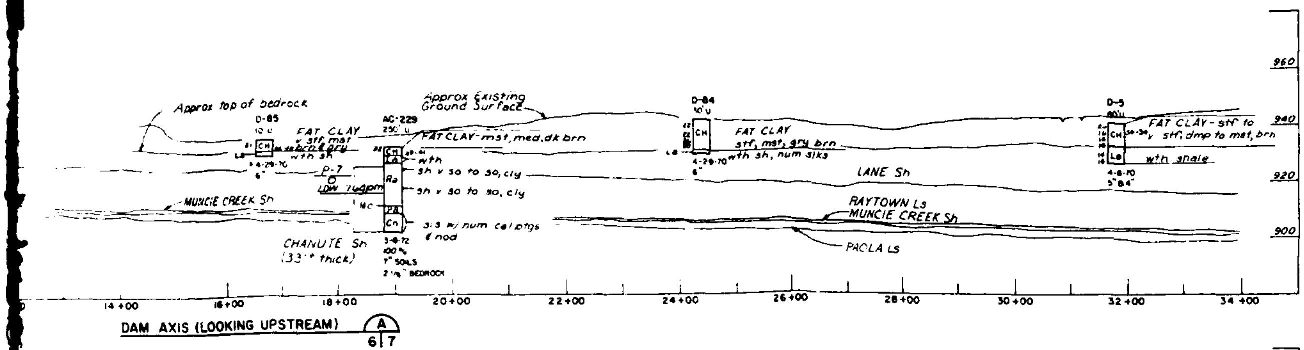
SEA LEVEL
FEET ABOVE MEAN SEA LEVEL
ELEVATION IN FEET
C-87
FAT CLAY
LEAN CLAY
SANDY LEAN CLAY
MUNCIE CREEK SH
CHANUTE SH
Approx top of bedrock
Approx existing ground surface
FLOOD CONTROL POOL EL 931
MULTIPURPOSE POOL EL 917
DAM AXIS (LOOKING UPSTREAM)
A
6 7
DAM AXIS (LOOKING UPSTREAM)
A
6 7
DAM AXIS (LOOKING UPSTREAM)
A
6 7

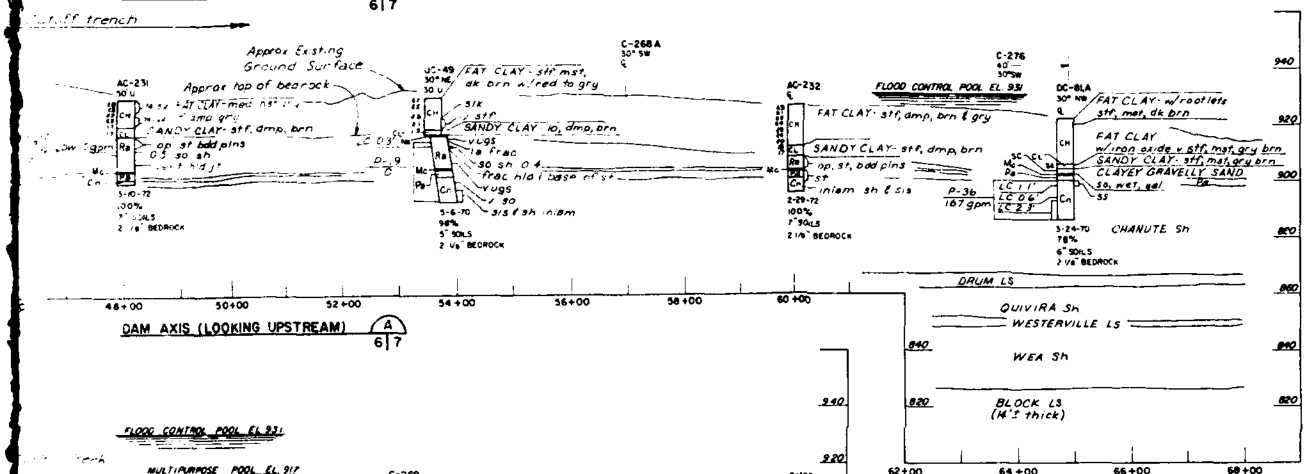
AD-A169 863 MULTIPLE-PURPOSE PROJECT OSAGE RIVER BASIN BIG BULL CREEK KANSAS HILLSDAL..(U) CORPS OF ENGINEERS KANSAS CITY MO KANSAS CITY DISTRICT F C WALBERG ET AL. SEP 84 2/4

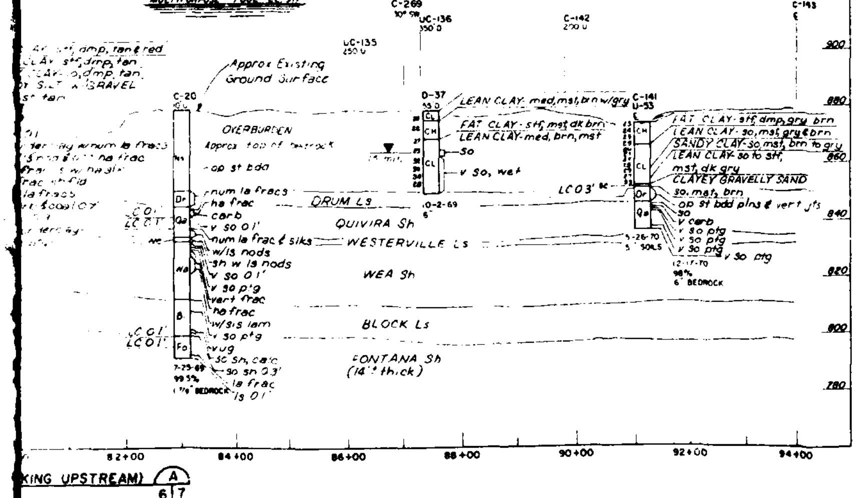
UNCLASSIFIED F/G 13/2 NL



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A







NOTES

1. General geologic column and legend shown on Dwg No 5
2. Boring locations shown on Dwg No 6
3. Logs of detached borings shown on Dwg Nos 10, 11, and 12 in order of ascending dam ℄ stationing.
4. Logs of explorations - Dam Axis - continued on Dwg No. 8.
5. Approx limits of grout curtain and cutoff trench shown on Dwg No. 9
6. Logs of borings for permanent piezometers shown on Dwg No 13

RECORD DRAWING

DECEMBER 1977

CONTRACT NO DACW41 76 C 0115

SYM	DESCRIPTION	DATE	APP'D
	Revised for "As Built" conditions	4/12/83	

REVISIONS

BIG BULL CREEK, KANSAS

HILLSDALE LAKE

STAGE I CONSTRUCTION

2

LOGS OF EXPLORATIONS
DAM AXIS

Dwg. No. 7

CORPS OF ENGINEERS
KANSAS CITY DISTRICT

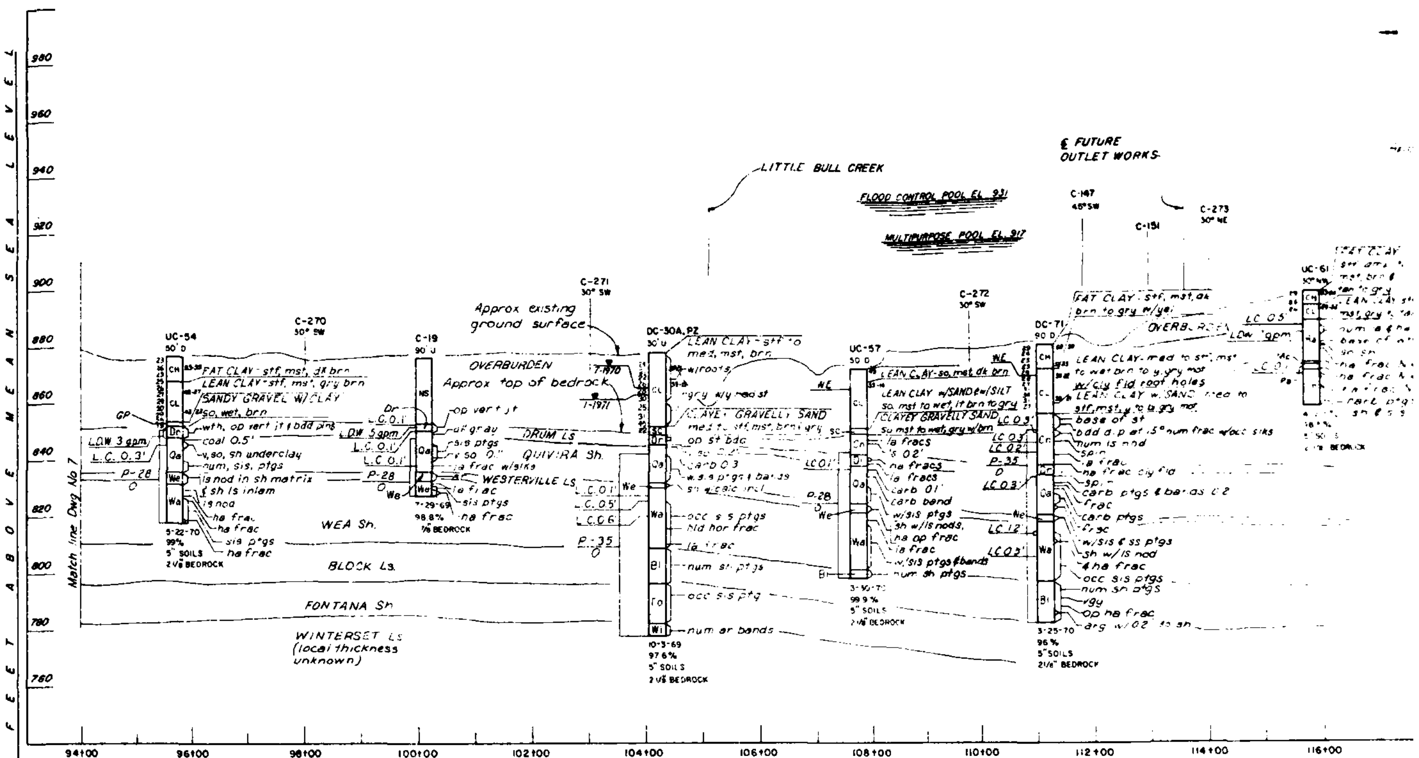
Scale: as shown

U. S. ARMY
FEBRUARY 1976

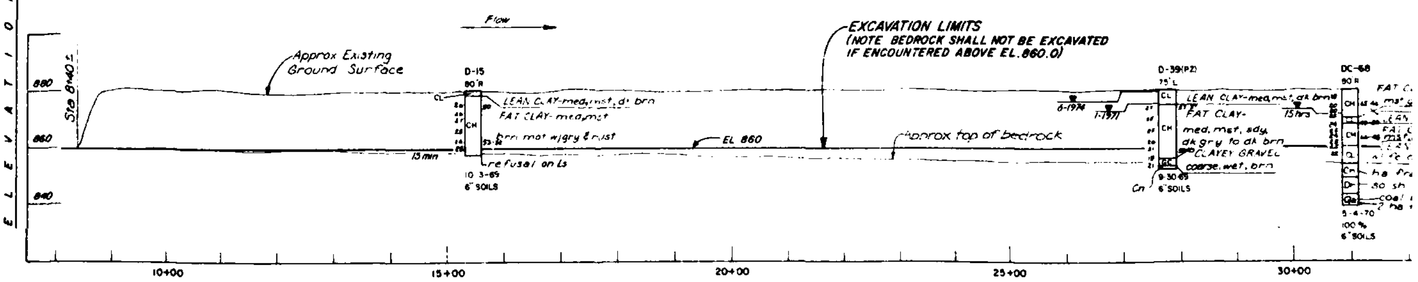
COMPILED BY R G S DRAWN BY J P M CHECKED BY R G S

FILE NO 0-15-467

PLATE NO 9

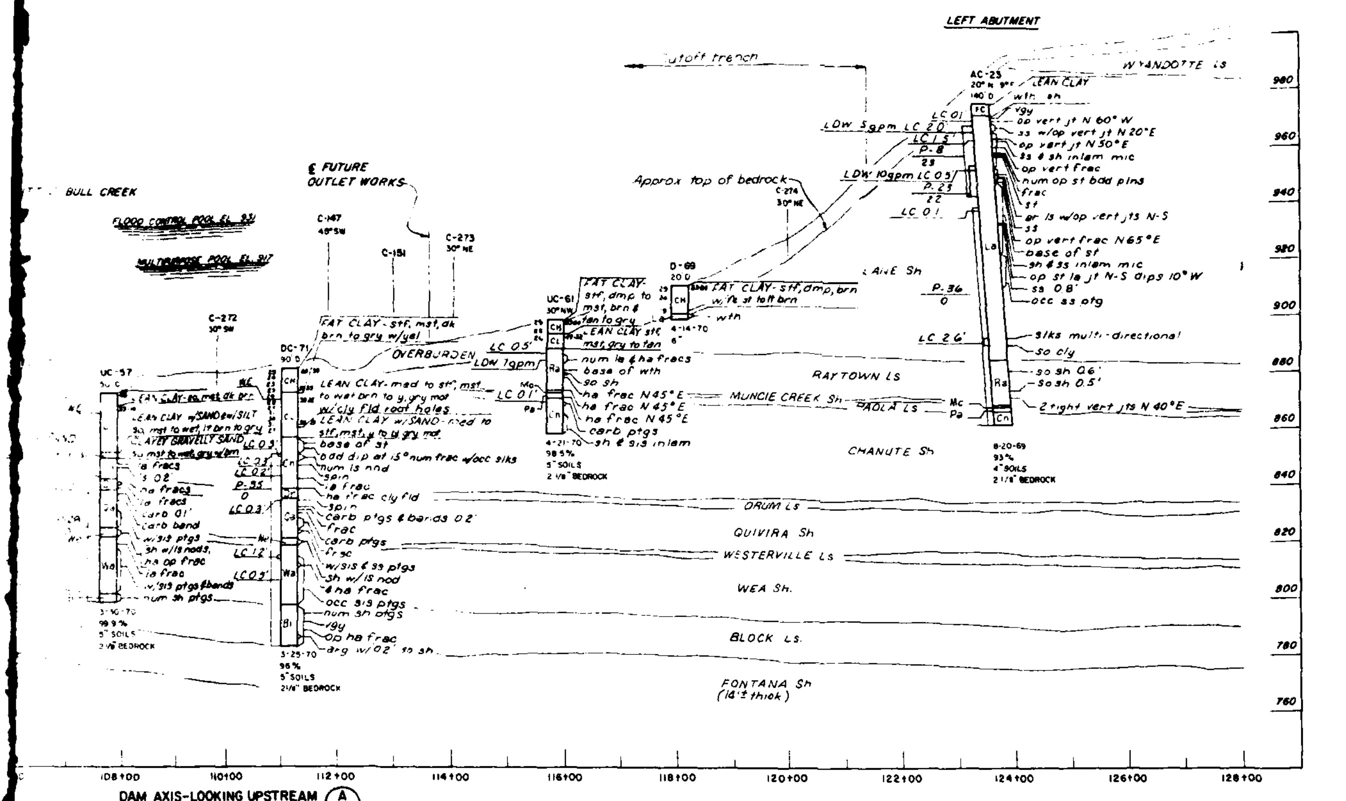


DAM AXIS-LOOKING UPSTREAM (A) 6|8

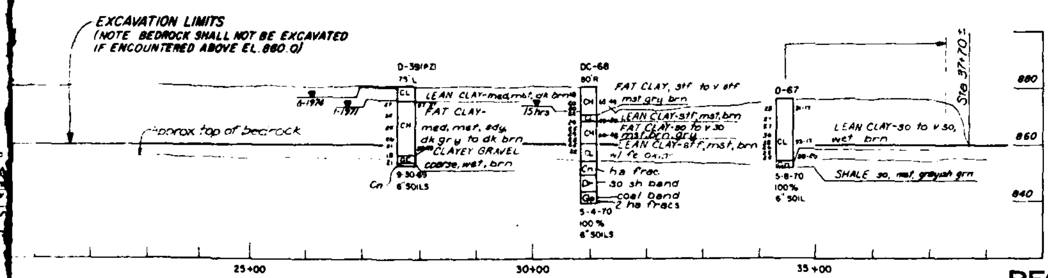


DIVERSION CHANNEL - ℄ PROFILE (B) 6|8

NOTES
1 General Geologic Column ...
Legend shown on Dwg N...
2 Boring locations shown on ...
3 Logs of detached borings ...
Dwg Nos ... and ... ...
dam ℄ stationing
4 Logs of exploration - Dam ...
continued on Dwg No 7
5 Approximate limits of gro...
cutoff trench are shown on D...
6 Logs of borings for perma...
piezometers shown on Dwg N...



DAM AXIS-LOOKING UPSTREAM A 6|8



DIVERSION CHANNEL - ℄ PROFILE B 6|8

NOTES:
1. General Geologic Column and Legend shown on Dwg. No. 5.
2. Boring locations shown on Dwg. No. 6
3. Logs of detached borings shown on Dwg. Nos. 10, 11 and 12 in order of ascending dam ℄ stationing.
4. Logs of exploration - Dam Axis are continued on Dwg. No 7
5. Approximate limits of grout curtain cutoff trench are shown on Dwg No 9
6. Logs of borings for permanent piezometers shown on Dwg No 13

RECORD DRAWING

DECEMBER 1977

CONTRACT NO DACW41-76-C-0115

SYM.	DESCRIPTION	DATE	APP'D
	Revised for "As Built" conditions		

REVISIONS

BIG BULL CREEK, KANSAS

HILLSDALE LAKE

STAGE I CONSTRUCTION

LOGS OF EXPLORATIONS DAM AXIS AND DIVERSION CHANNEL

Dwg. No. 8

CORPS OF ENGINEERS KANSAS CITY DISTRICT

Scale: as shown

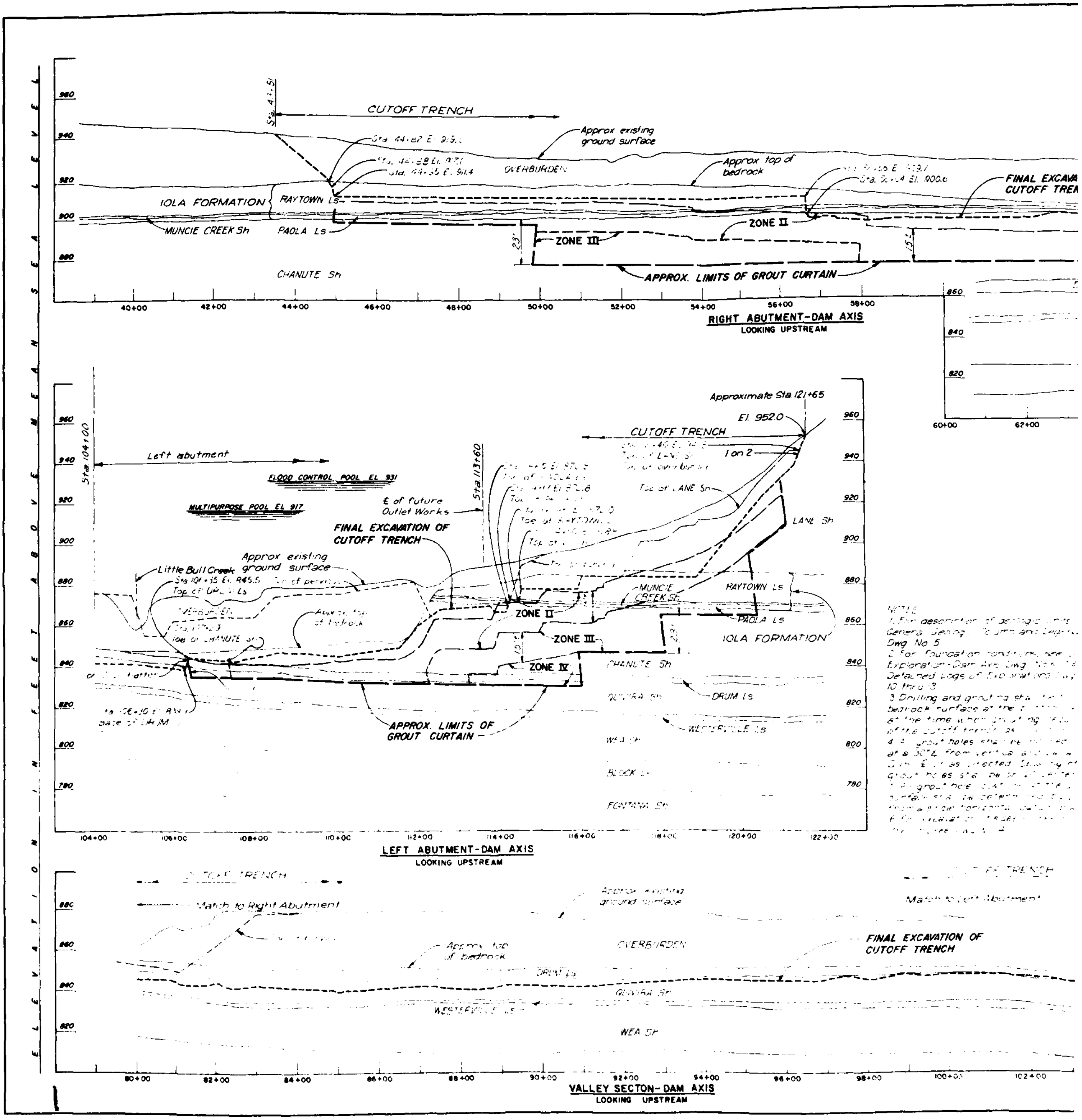
U S ARMY FEBRUARY 1976

Submitted | Recommended | Approved

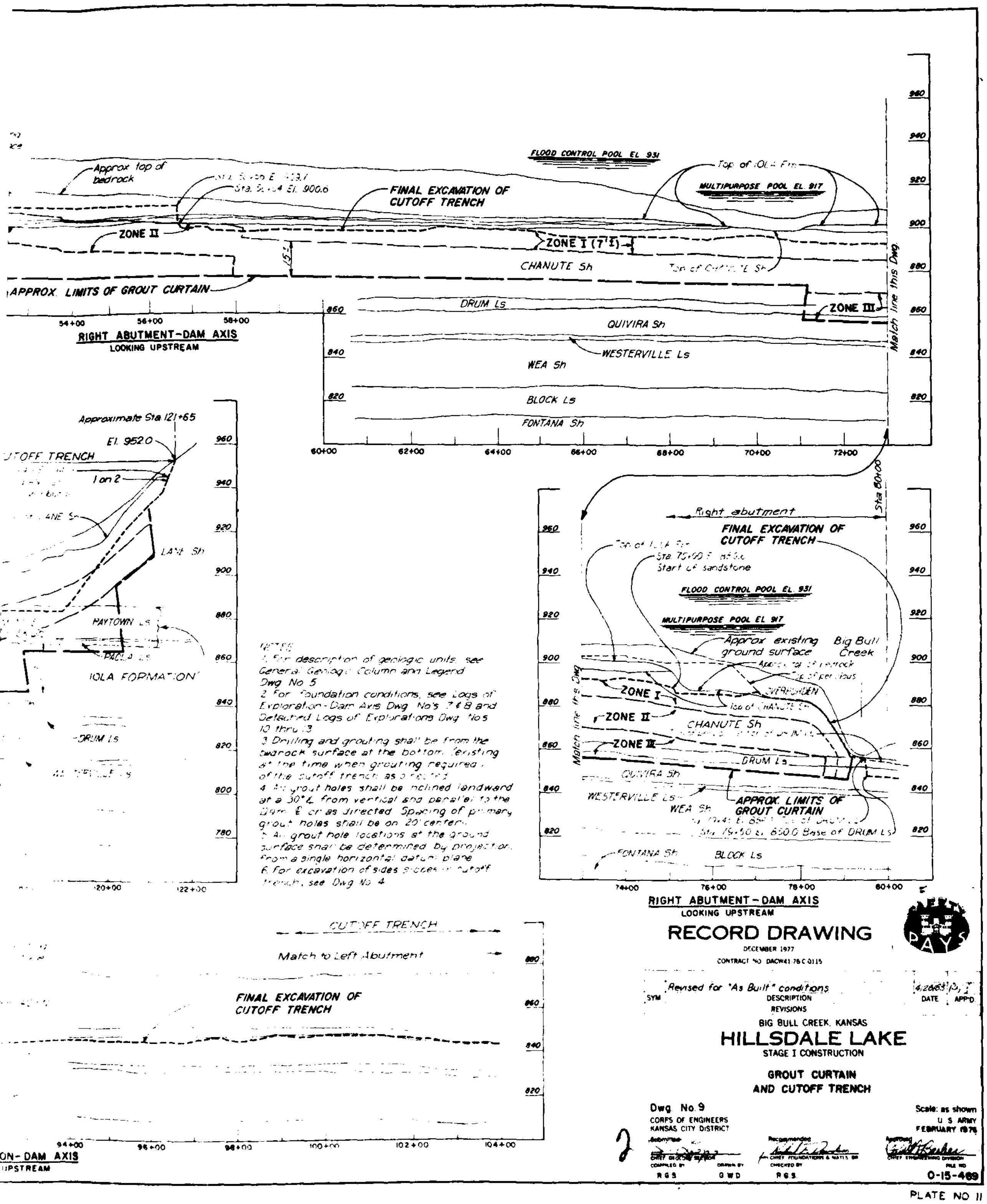
COMPILED BY R G S | DRAWN BY J P M | CHECKED BY R G S

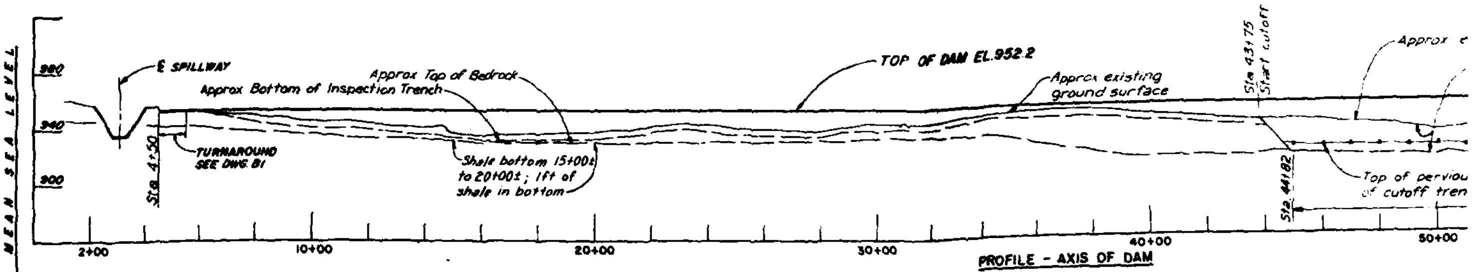
FILE NO 0-15-468

PLATE NO 10

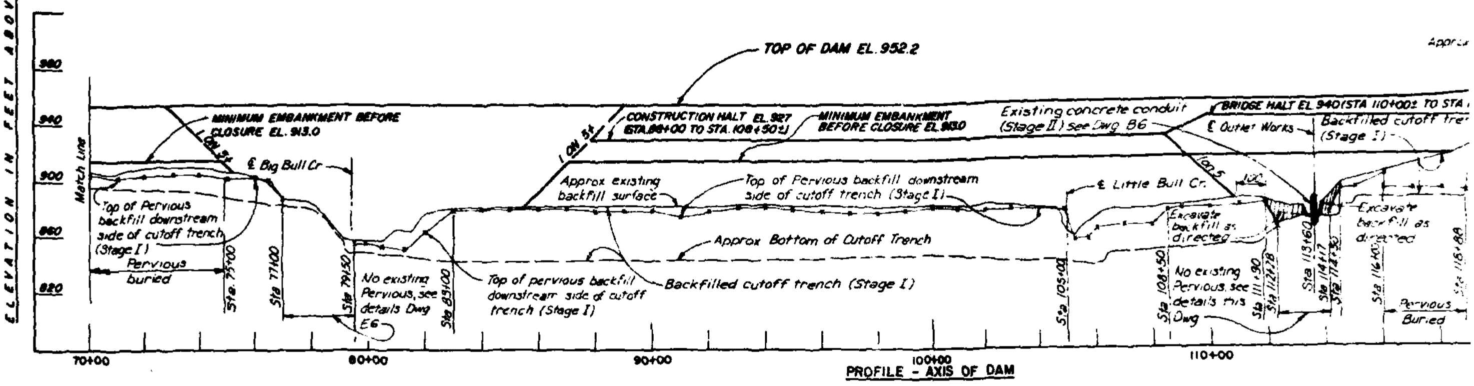


ELEVATION ABOVE MEAN SEA LEVEL IN FEET
Sta 44+51
CUTOFF TRENCH
Approx existing ground surface
OVERBURDEN
Approx top of bedrock
FINAL EXCAVATION OF CUTOFF TRENCH
IOLA FORMATION
RAYTOWN Ls
MUNCIE CREEK Sh
PAOLA Ls
ZONE III
ZONE II
23'
15'
CHANUTE Sh
APPROX. LIMITS OF GROUT CURTAIN
RIGHT ABUTMENT-DAM AXIS
LOOKING UPSTREAM
Approximate Sta 121+65
El. 952.0
Sta 104+00
Left abutment
FLOOD CONTROL POOL EL 931
MULTIPURPOSE POOL EL 917
℄ of future Outlet Works
Sta 113+60
FINAL EXCAVATION OF CUTOFF TRENCH
1 on 2
Top of LANE Sh
LANE Sh
Little Bull Creek
Approx existing ground surface
Sta 104+35 El. 845.5
RAYTOWN Ls
MUNCIE CREEK Sh
PAOLA Ls
IOLA FORMATION
ZONE II
ZONE III
ZONE IV
CHANUTE Sh
DRUM Ls
APPROX. LIMITS OF GROUT CURTAIN
LEFT ABUTMENT-DAM AXIS
LOOKING UPSTREAM
Match to Right Abutment
Match to Left Abutment
Approx top of bedrock
OVERBURDEN
FINAL EXCAVATION OF CUTOFF TRENCH
WEA Sh
VALLEY SECTON-DAM AXIS
LOOKING UPSTREAM

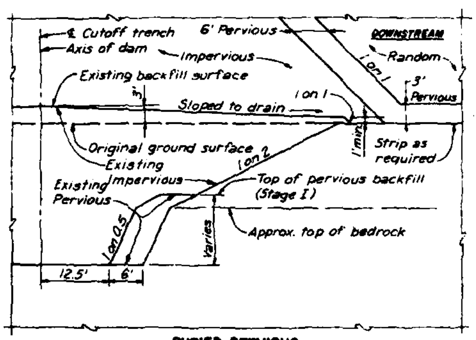

FLOOD CONTROL POOL EL 931
MULTIPURPOSE POOL EL 917
Top of IOLA Fm
Approx top of bedrock
Sta 54+54 El 900.6
FINAL EXCAVATION OF CUTOFF TRENCH
ZONE II
ZONE I (7'±)
CHANUTE Sh
APPROX. LIMITS OF GROUT CURTAIN
ZONE III
DRUM Ls
QUIVIRA Sh
WESTERVILLE Ls
WEA Sh
BLOCK Ls
FONTANA Sh
Match line this Dwg
RIGHT ABUTMENT-DAM AXIS
LOOKING UPSTREAM
Approximate Sta 121+65
El. 952.0
CUTOFF TRENCH
1 on 2
LANE Sh
PAYTOWN Ls
PAOLA Ls
IOLA FORMATION
DRUM Ls
Right abutment
Sta 80+00
Sta 75+00 El 935.0
Start of sandstone
Approx existing ground surface
Big Bull Creek
ZONE I
ZONE II
ZONE III
CHANUTE Sh
DRUM Ls
QUIVIRA Sh
WESTERVILLE Ls
WEA Sh
APPROX. LIMITS OF GROUT CURTAIN
Sta 79+50 El 850.0 Base of DRUM Ls
FONTANA Sh
BLOCK Ls
NOTES
1. For description of geologic units see General Geologic Column and Legend Dwg No 5
2. For foundation conditions, see Logs of Exploration - Dam Axis Dwg No's 7 & 8 and Detailed Logs of Explorations Dwg Nos 10 thru 13
3. Drilling and grouting shall be from the bedrock surface at the bottom existing at the time when grouting required of the cutoff trench as directed
4. All grout holes shall be inclined landward at a 30° from vertical and parallel to the Dam ℄ or as directed. Spacing of primary grout holes shall be on 20' centers
5. All grout hole locations at the ground surface shall be determined by projection from a single horizontal datum plane
6. For excavation of sides slopes in cutoff trench, see Dwg No 4
CUTOFF TRENCH
Match to Left Abutment
FINAL EXCAVATION OF CUTOFF TRENCH
ON-DAM AXIS
UPSTREAM
RECORD DRAWING
DECEMBER 1977
CONTRACT NO DACW41 76 C 0115
Revised for "As Built" conditions
SYM DESCRIPTION DATE APPD
REVISIONS
BIG BULL CREEK, KANSAS
HILLSDALE LAKE
STAGE I CONSTRUCTION
GROUT CURTAIN
AND CUTOFF TRENCH
Dwg No. 9
CORPS OF ENGINEERS
KANSAS CITY DISTRICT
Scale: as shown
U S ARMY
FEBRUARY 1976
0-15-469
PLATE NO 11



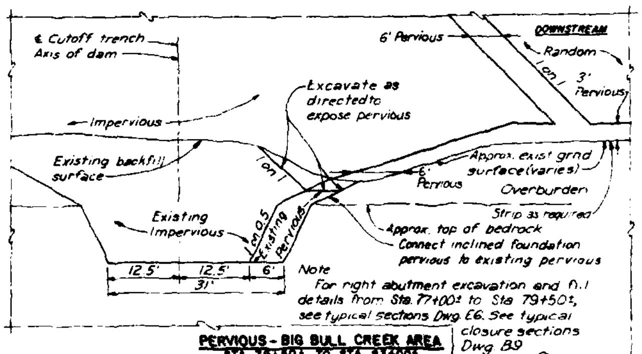
PROFILE - AXIS OF DAM



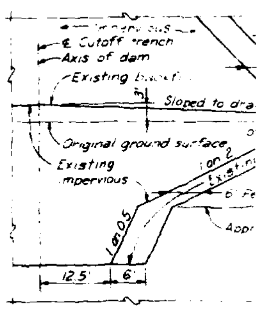
PROFILE - AXIS OF DAM



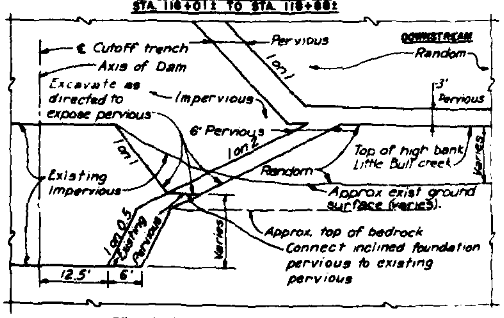
BURIED PERVIOUS
STA. 44+82± TO STA. 75+00±
STA. 116+01± TO STA. 118+88±



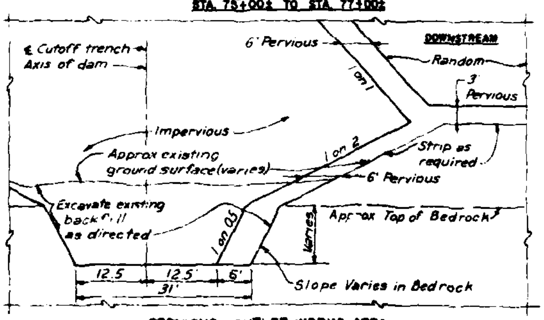
PERVIOUS - BIG BULL CREEK AREA
STA. 79+50± TO STA. 83+00±
STA. 75+00± TO STA. 77+00±



PERVIOUS
STA. 83+00±
STA. 108+50±
STA. 114+50±



PERVIOUS - LITTLE BULL CREEK AREA
STA. 105+00± TO STA. 108+50±



PERVIOUS - OUTLET WORKS AREA
STA. 111+90± TO STA. 114+50±

Note:
The stream banks of Little Bull Creek beneath the embankment shall be excavated to 1 on 3 slopes or as directed.

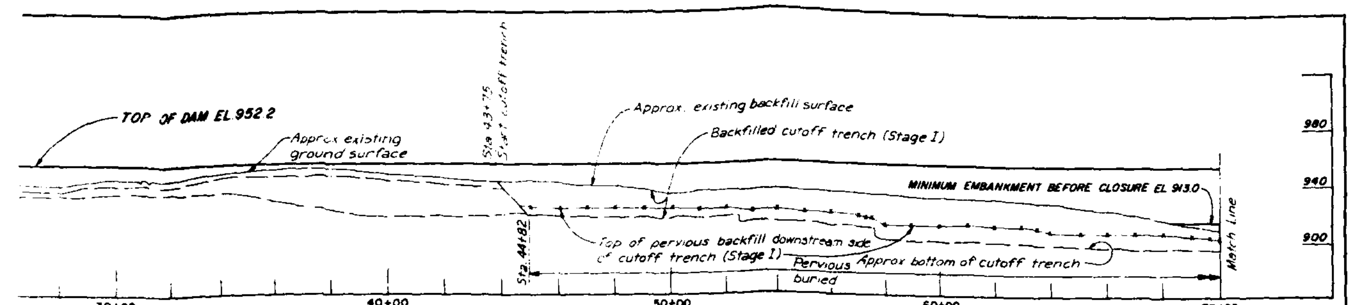
Note
For backfill details in outlet works area, see Dwg No B6

TABLE A
EXISTING INCLINED PERVIOUS

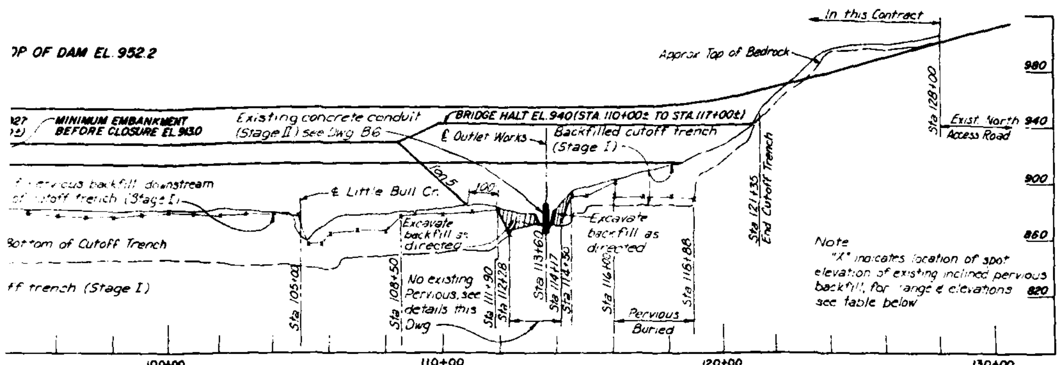
STATION	RANGE DOWNSTREAM	ELEV. TOP OF PERVIOUS
44+82		921.6
46+00		921.7
47+00		921.9
48+00		921.8
49+00		921.7
50+00		921.6
51+00		921.1
52+00		921.0
53+00		919.9
54+00		919.6
55+00		918.4
56+00		918.1
57+00		917.0
57+24		915.4
57+50		914.0
58+00		910.4
59+00		905.8
60+00		910.6
61+00		911.1
62+00		909.8
63+00		910.1
63+24		909.9
64+00		907.6
65+10		[illegible]
66+00		[illegible]
67+00		[illegible]

EXIS'

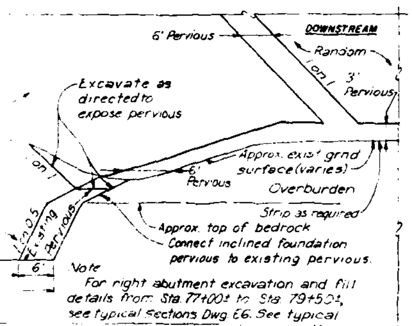
STATION
68+00
69+00
69+65
70+00
71+00
72+50
73+00
74+50
75+00
76+00
76+50
77+50
78+50
79+82
80+50
81+25
82+00
83+00
84+00
85+00
86+00
87+00
88+00
89+00
90+00
91+00



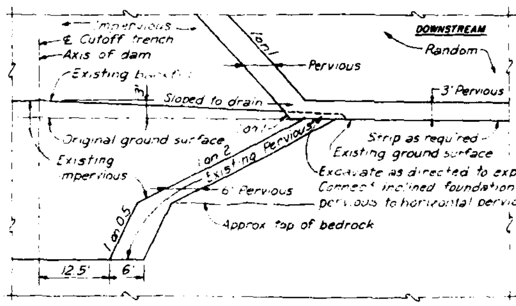
PROFILE - AXIS OF DAM



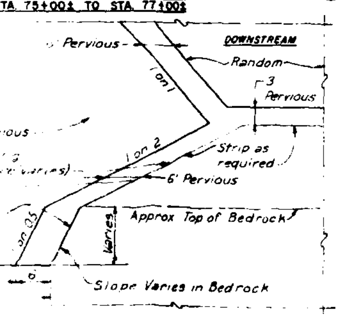
PROFILE - AXIS OF DAM



PERVIOUS - BIG BULL CREEK AREA
STA. 79+50± TO STA. 83+00±
STA. 75+00± TO STA. 77+00±



PERVIOUS - MAIN VALLEY
STA. 83+00± TO STA. 105+00±
STA. 108+50± TO STA. 111+90±
STA. 114+50± TO STA. 116+00±



PERVIOUS - OUTLET WORKS AREA
STA. 111+90± TO STA. 114+90±

...for backfill details in outlet works area, see Dwg No B6

TABLE A
EXISTING INCLINED PERVIOUS

STATION	RANGE DOWNSTREAM	ELEV TOP OF PERVIOUS
44+82		921.6
46+00		921.7
47+00		921.9
48+00		921.8
49+00		921.7
50+00		921.6
51+00		921.1
52+00		921.0
53+00		919.9
54+00		919.8
55+00		918.6
56+00		918.1
57+00		917.0
57+24		915.4
57+50		914.8
58+00		910.4
59+00		909.5
60+00		910.6
61+00		911.1
62+00		909.8
63+00		910.1
63+54		908.9
64+00		907.6
65+00		906.7
66+00		906.2
67+00		906.8

TABLE A (CONT.)
EXISTING INCLINED PERVIOUS

STATION	RANGE DOWNSTREAM	ELEV TOP OF PERVIOUS
68+00		906.1
69+00		904.7
69+65		903.2
70+30		902.5
71+00		900.5
72+00		902.8
73+00		901.8
74+00		903.0
75+00		900.0
76+00	40.9-46.9	900.0
76+50		898.2
77+00	12.5-18.5	886.2
79+50	17.0-23.0	855.0
79+82		853.9
80+50		852.5
81+25	25.8-31.8	849.6
82+00		862.0
83+00	78.2-84.2	876.0
84+00		876.9
85+00	78.0-84.0	878.6
86+00		878.6
87+00		878.5
88+00		877.7
89+00		876.1
90+00	71.4-77.4	877.1
91+00		873.4

TABLE A (CONT)
EXISTING INCLINED PERVIOUS

STATION	RANGE DOWNSTREAM	ELEV. TOP OF PERVIOUS
92+00		877.8
93+00		879.1
94+00		878.9
95+00	75.0-81.0	878.1
96+00		876.2
97+00		875.6
98+00		876.0
99+00		877.8
100+00	69.5-75.5	878.5
101+00		877.8
102+50		876.2
103+00		877.7
104+00		877.1
104+95	79.0-85.0	876.8
105+26	36.5-42.5	856.0
105+75	40.2-46.2	856.0
106+00	52.5-58.5	863.0
107+00	49.8-55.8	865.0
108+00		865.0
108+50	67.7-73.7	875.0
109+00		876.2
[illegible]	67.[illegible]-73.[illegible]	876.4
111+00		879.6
111+89	59.0-65.0	882.3
112+28	4.0-20.0	865.7
114+17	15.0-21.0	873.0
114+50	33.2-39.2	889.5
115+00	40.9-46.9	894.5
116+00	44.0-50.0	899.5
116+01		889.4
117+00		888.5
118+00		888.2
118+88		888.3

RECORD DRAWING
JULY 1982
CONTRACT NO. DACW41 78 C 0113

SYM	DESCRIPTION	DATE	APP'D
	Revised for "As Built" conditions	6/28/83	

REVISIONS

BIG BULL CREEK, KANSAS
HILLSDALE LAKE
STAGE III CONSTRUCTION

DAM AXIS PROFILE AND DETAILS
EXISTING CUTOFF TRENCH

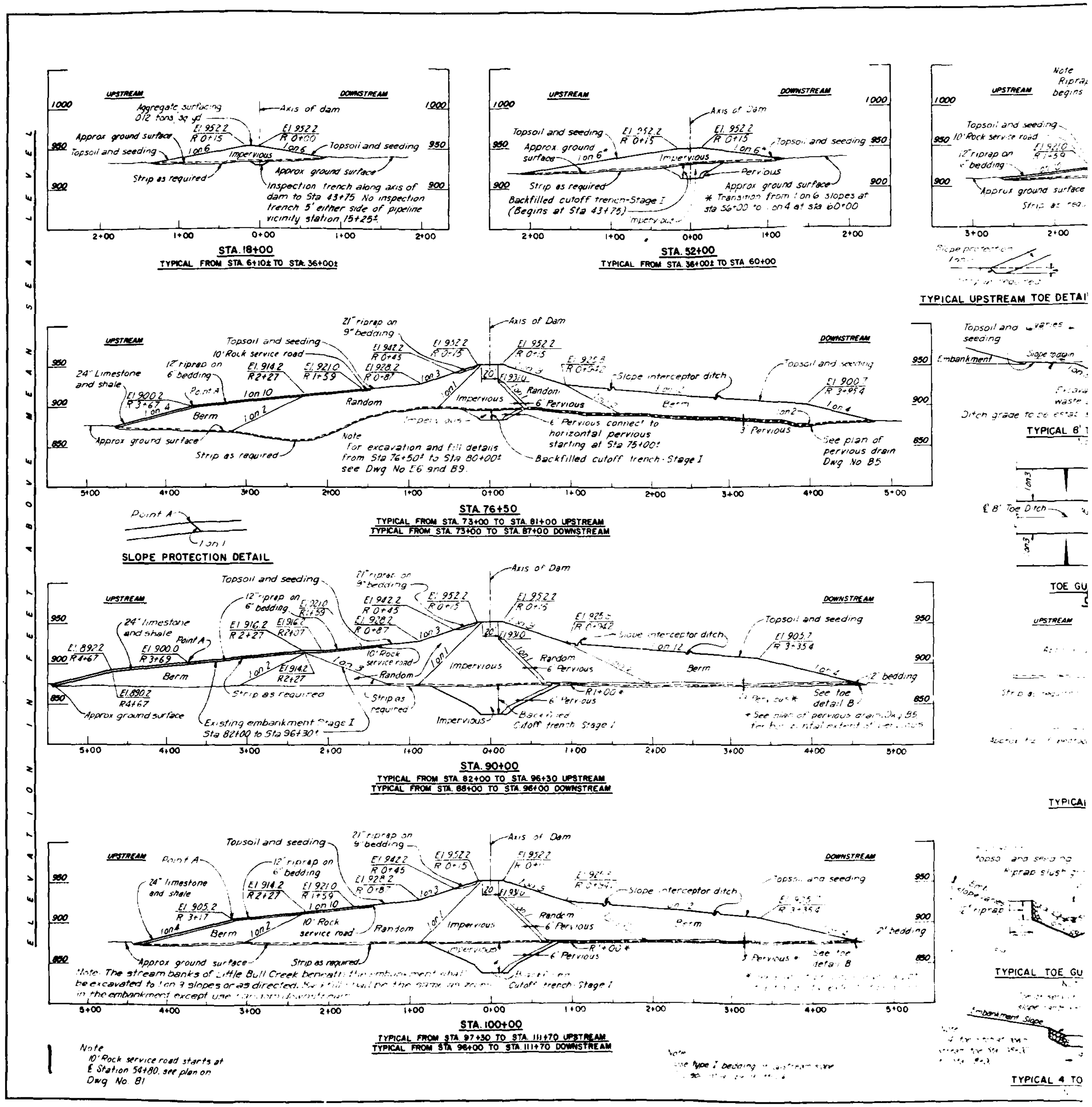
Dwg No. B3
CORPS OF ENGINEERS
KANSAS CITY DISTRICT

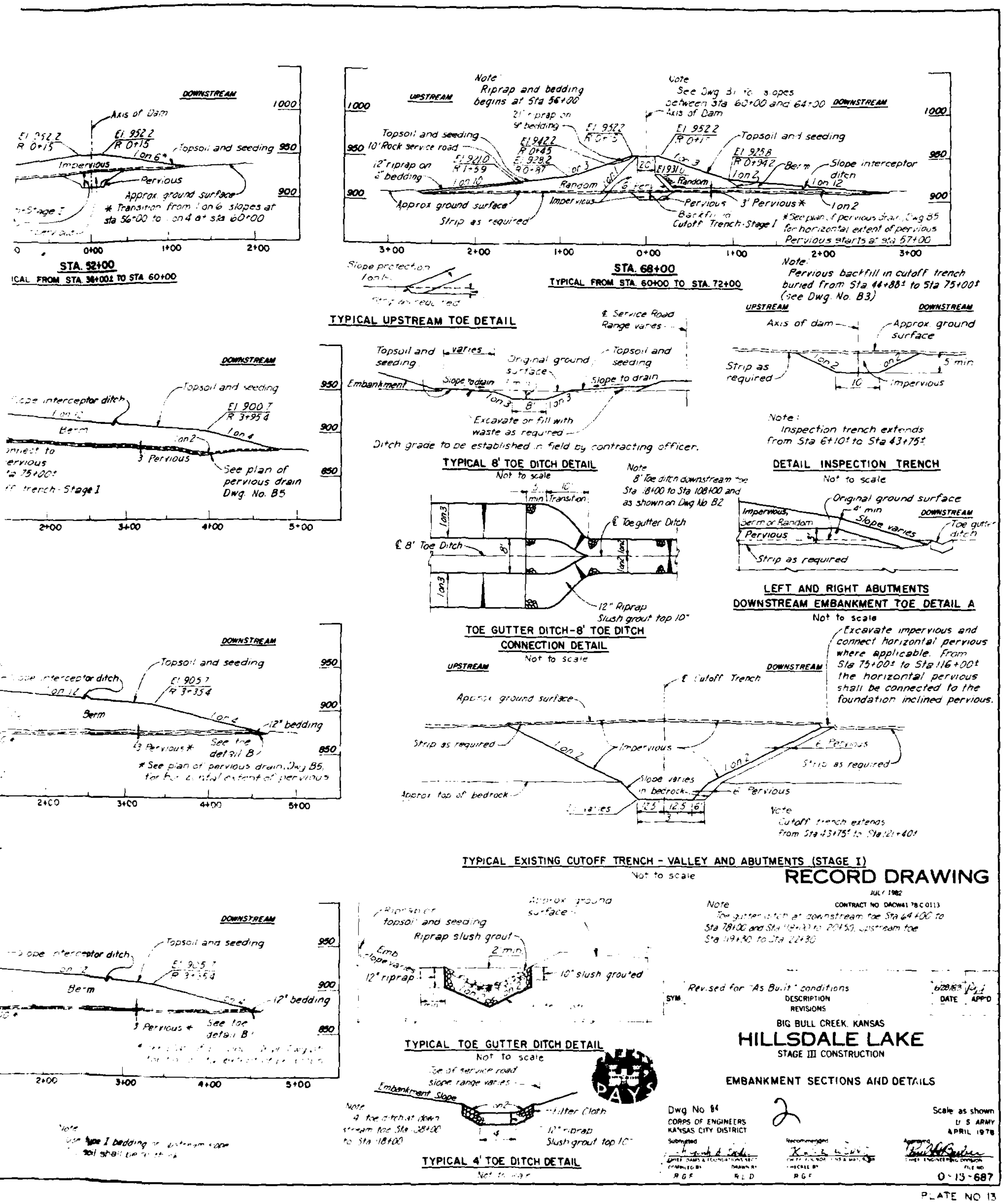
Scale: as shown
U. S. ARMY
APRIL 1978

Submitted: Chief, Dams & Foundations Sect
Recommended: Chief, Foundations & Materials Br
Approved: Chief, Engineering Division
Compiled by RGF; Drawn by CRT; Checked by RGF

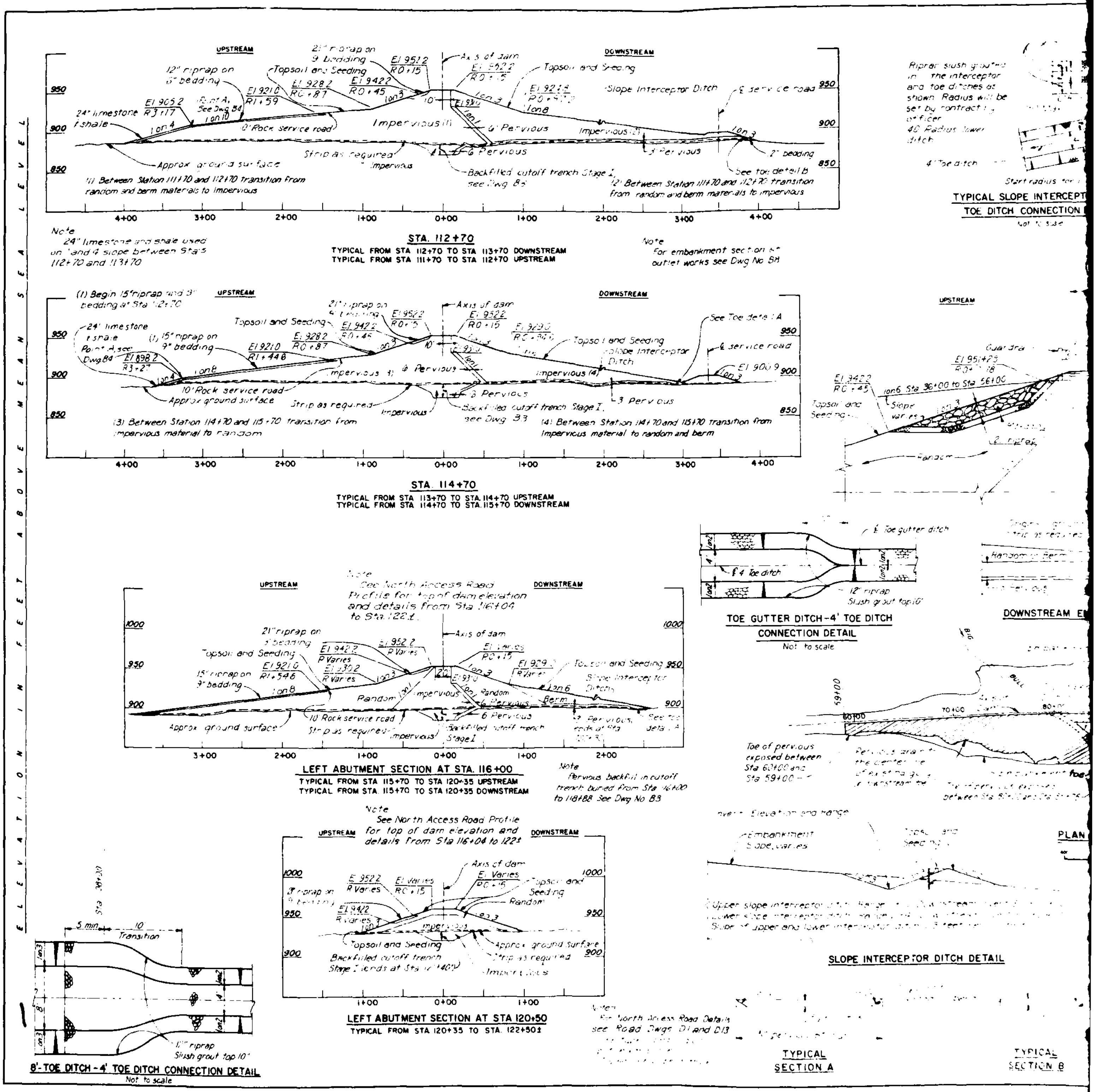
0-15-666

PLATE NO. 12


ELEVATION IN FEET ABOVE MEAN SEA LEVEL
UPSTREAM
DOWNSTREAM
Aggregate surfacing 0.12 tons sq yd
Axis of dam
El 952.2 R 0+15
El 952.2 R 0+00
Approx ground surface
Topsoil and seeding
Impervious
Strip as required
Inspection trench along axis of dam to Sta 43+75. No inspection trench 5' either side of pipeline vicinity station 15+25±
STA. 18+00
TYPICAL FROM STA. 6+10± TO STA. 36+00±
Backfilled cutoff trench-Stage I (Begins at Sta 43+75)
Pervious
* Transition from 1 on 6 slopes at sta 56+00 to 1 on 4 at sta 60+00
STA. 52+00
TYPICAL FROM STA. 36+00± TO STA 60+00
21" riprap on 9" bedding
10' Rock service road
12" riprap on 6" bedding
24" Limestone and shale
Point A
Berm
Random
Slope interceptor ditch
6" Pervious
6" Pervious connect to horizontal pervious starting at Sta 75+00±
Note For excavation and fill details from Sta 76+50± to Sta 80+00± see Dwg No E6 and B9.
Backfilled cutoff trench-Stage I
See plan of pervious drain Dwg No B5
STA. 76+50
TYPICAL FROM STA. 73+00 TO STA. 81+00 UPSTREAM
TYPICAL FROM STA. 73+00 TO STA. 87+00 DOWNSTREAM
SLOPE PROTECTION DETAIL
Existing embankment Stage I Sta 82+00 to Sta 96+30±
Backfilled cutoff trench Stage I
See toe detail B
2' bedding
* See plan of pervious drain Dwg B5 for horizontal extent of pervious
STA. 90+00
TYPICAL FROM STA. 82+00 TO STA. 96+30 UPSTREAM
TYPICAL FROM STA. 88+00 TO STA. 96+00 DOWNSTREAM
Note: The stream banks of Little Bull Creek beneath the embankment shall be excavated to 1 on 3 slopes or as directed.
STA. 100+00
TYPICAL FROM STA. 97+30 TO STA. 111+70 UPSTREAM
TYPICAL FROM STA. 96+00 TO STA. 111+70 DOWNSTREAM
Note 10' Rock service road starts at ℄ Station 54+80. see plan on Dwg No. B1
TYPICAL UPSTREAM TOE DETAIL
TYPICAL 8' TOE DITCH
TOE GUTTER
TYPICAL TOE GUTTER
TYPICAL 4' TOE DITCH



DOWNSTREAM
Axis of Dam
El 952.2 R 0+15
Topsoil and seeding
Impervious
Pervious
Approx ground surface
* Transition from 1 on 6 slopes at sta 56+00 to 1 on 4 at sta 60+00
STA. 52+00
TYPICAL FROM STA. 38+00± TO STA. 60+00
UPSTREAM
Note
Riprap and bedding begins at Sta 56+00
Note
See Dwg B1 for slopes between Sta 60+00 and 64+00
Topsoil and seeding
10' Rock service road
12" riprap on 6" bedding
Approx ground surface
Strip as required
Random
Impervious
Pervious
3' Pervious *
Backfill in Cutoff Trench-Stage I
* See plan of pervious drain, Dwg B5 for horizontal extent of pervious. Pervious starts at sta 57+00
STA. 68+00
TYPICAL FROM STA. 60+00 TO STA. 72+00
Note
Pervious backfill in cutoff trench buried from Sta 44+88± to Sta 75+00± (See Dwg. No. B3)
TYPICAL UPSTREAM TOE DETAIL
Topsoil and seeding
Original ground surface
Embankment
Slope to drain
Excavate or fill with waste as required
Ditch grade to be established in field by contracting officer.
TYPICAL 8' TOE DITCH DETAIL
Not to scale
Axis of dam
Approx ground surface
Strip as required
Impervious
Note:
Inspection trench extends from Sta 6+10± to Sta 43+75±
DETAIL INSPECTION TRENCH
Not to scale
Slope interceptor ditch
El 900.7 R 3+95.4
Berm
See plan of pervious drain Dwg. No. B5
Note
8' Toe ditch downstream toe Sta 18+00 to Sta 108+00 and as shown on Dwg No B2
℄ Toe gutter Ditch
℄ 8' Toe Ditch
12" Riprap Slush grout top 10"
TOE GUTTER DITCH-8' TOE DITCH CONNECTION DETAIL
Not to scale
Original ground surface
Impervious, Berm or Random
Pervious
Slope varies
Toe gutter ditch
Strip as required
LEFT AND RIGHT ABUTMENTS DOWNSTREAM EMBANKMENT TOE DETAIL A
Not to scale
Excavate impervious and connect horizontal pervious where applicable. From Sta 75+00± to Sta 116+00± the horizontal pervious shall be connected to the foundation inclined pervious.
El 905.7 R 3+35.4
12" bedding
See toe detail B
* See plan of pervious drain, Dwg B5, for horizontal extent of pervious
℄ Cutoff Trench
Approx ground surface
Strip as required
Impervious
Slope varies in bedrock
Approx top of bedrock
Pervious
Note
Cutoff trench extends from Sta 43+75± to Sta 121+40±
TYPICAL EXISTING CUTOFF TRENCH - VALLEY AND ABUTMENTS (STAGE I)
Not to scale
RECORD DRAWING
JULY 1982
CONTRACT NO. DACW41 78 C 0113
Note
Toe gutter ditch at downstream toe Sta 64+00 to Sta 78+00 and Sta 118+30 to 20+50, upstream toe Sta 19+30 to Sta 22+30
Riprap slush grout
10" slush grouted
12" riprap
TYPICAL TOE GUTTER DITCH DETAIL
Not to scale
Revised for "As Built" conditions
BIG BULL CREEK, KANSAS
HILLSDALE LAKE
STAGE III CONSTRUCTION
EMBANKMENT SECTIONS AND DETAILS
Embankment Slope
Filter Cloth
12" riprap Slush grout top 10"
TYPICAL 4' TOE DITCH DETAIL
Dwg No B4
CORPS OF ENGINEERS KANSAS CITY DISTRICT
Scale as shown
U. S. ARMY
APRIL 1978
O-15-687
PLATE NO 13



ELEVATION IN FEET ABOVE MEAN SEA LEVEL
UPSTREAM
DOWNSTREAM
Axis of dam
24" limestone & shale
12" riprap on 6" bedding
21" riprap on 9" bedding
Topsoil and Seeding
Impervious
10' Rock service road
Approx ground surface
Strip as required
Pervious
Backfilled cutoff trench Stage I, see Dwg B3
Slope Interceptor Ditch
℄ service road
2" bedding
See toe detail B
(1) Between Station 111+70 and 112+70 transition from random and berm materials to impervious
(2) Between Station 111+70 and 112+70 transition from random and berm materials to impervious
Note
24" limestone and shale used on 1 and 4 slope between Sta's 112+70 and 113+70
STA. 112+70
TYPICAL FROM STA 112+70 TO STA 113+70 DOWNSTREAM
TYPICAL FROM STA 111+70 TO STA 112+70 UPSTREAM
Note
For embankment section at outlet works see Dwg No B8
(1) Begin 15" riprap and 9" bedding at Sta 112+70
(1) 15" riprap on 9" bedding
See Toe detail A
(3) Between Station 114+70 and 115+70 transition from impervious material to random
(4) Between Station 114+70 and 115+70 transition from impervious material to random and berm
STA. 114+70
TYPICAL FROM STA 113+70 TO STA 114+70 UPSTREAM
TYPICAL FROM STA 114+70 TO STA 115+70 DOWNSTREAM
Random
Berm
LEFT ABUTMENT SECTION AT STA. 116+00
TYPICAL FROM STA 115+70 TO STA 120+35 UPSTREAM
TYPICAL FROM STA 115+70 TO STA 120+35 DOWNSTREAM
Note
Pervious backfill in cutoff trench buried from Sta 116+00 to 118+88 See Dwg No B3
Note
See North Access Road Profile for top of dam elevation and details from Sta 116+04 to 122±
LEFT ABUTMENT SECTION AT STA 120+50
TYPICAL FROM STA 120+35 TO STA 122+50±
8'-TOE DITCH - 4' TOE DITCH CONNECTION DETAIL
Not to scale
TOE GUTTER DITCH-4' TOE DITCH CONNECTION DETAIL
Not to scale
12" riprap
Slush grout top 10'
Riprap slush grouted in the interceptor and toe ditches as shown. Radius will be set by contracting officer
40' Radius lower ditch
4' Toe ditch
TYPICAL SLOPE INTERCEPT
TOE DITCH CONNECTION
DOWNSTREAM E
Toe of pervious exposed between Sta 60+00 and Sta 59+00
PLAN
Embankment Slope, varies
Topsoil and Seeding
SLOPE INTERCEPTOR DITCH DETAIL
TYPICAL SECTION A
TYPICAL SECTION B

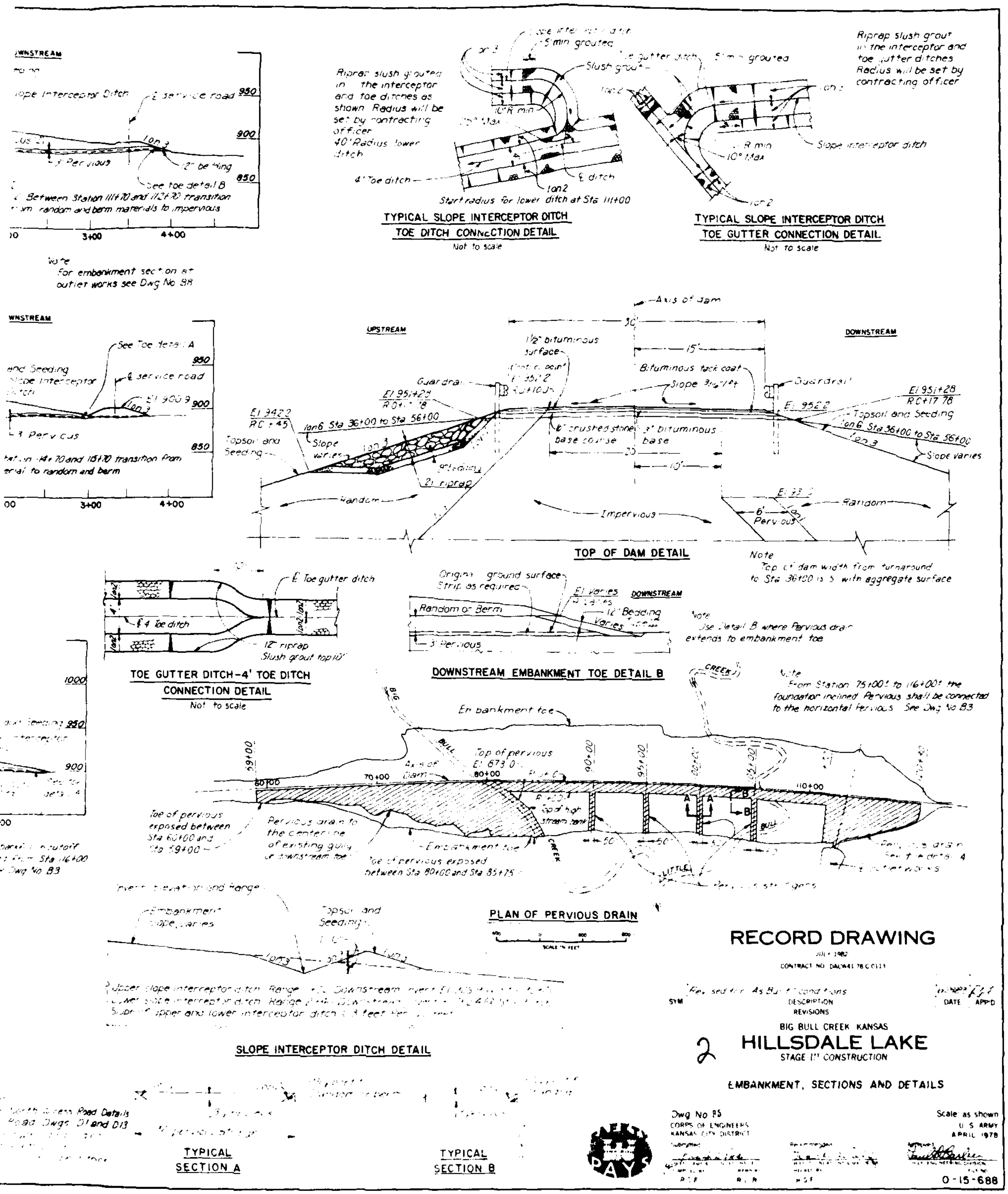
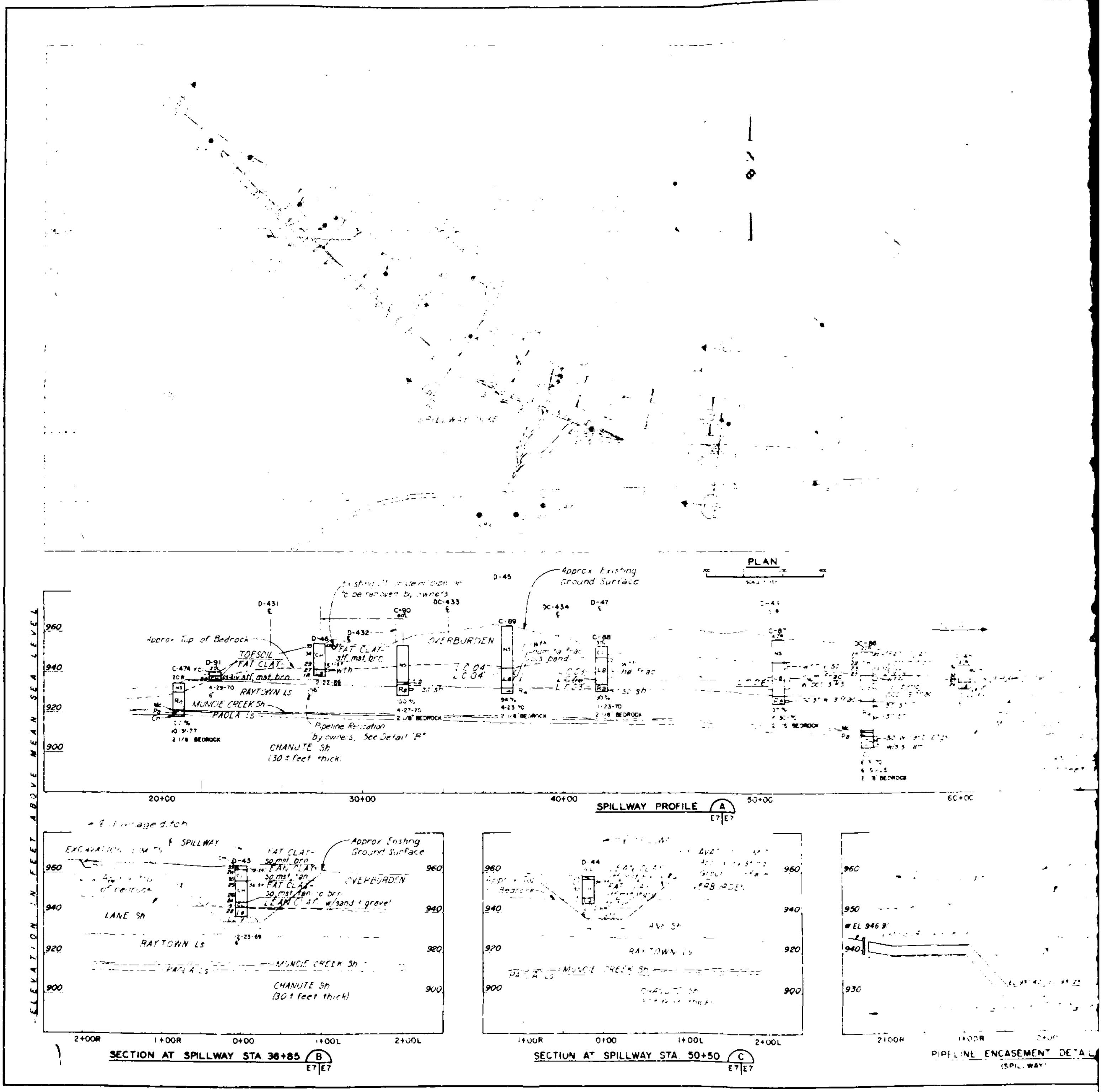
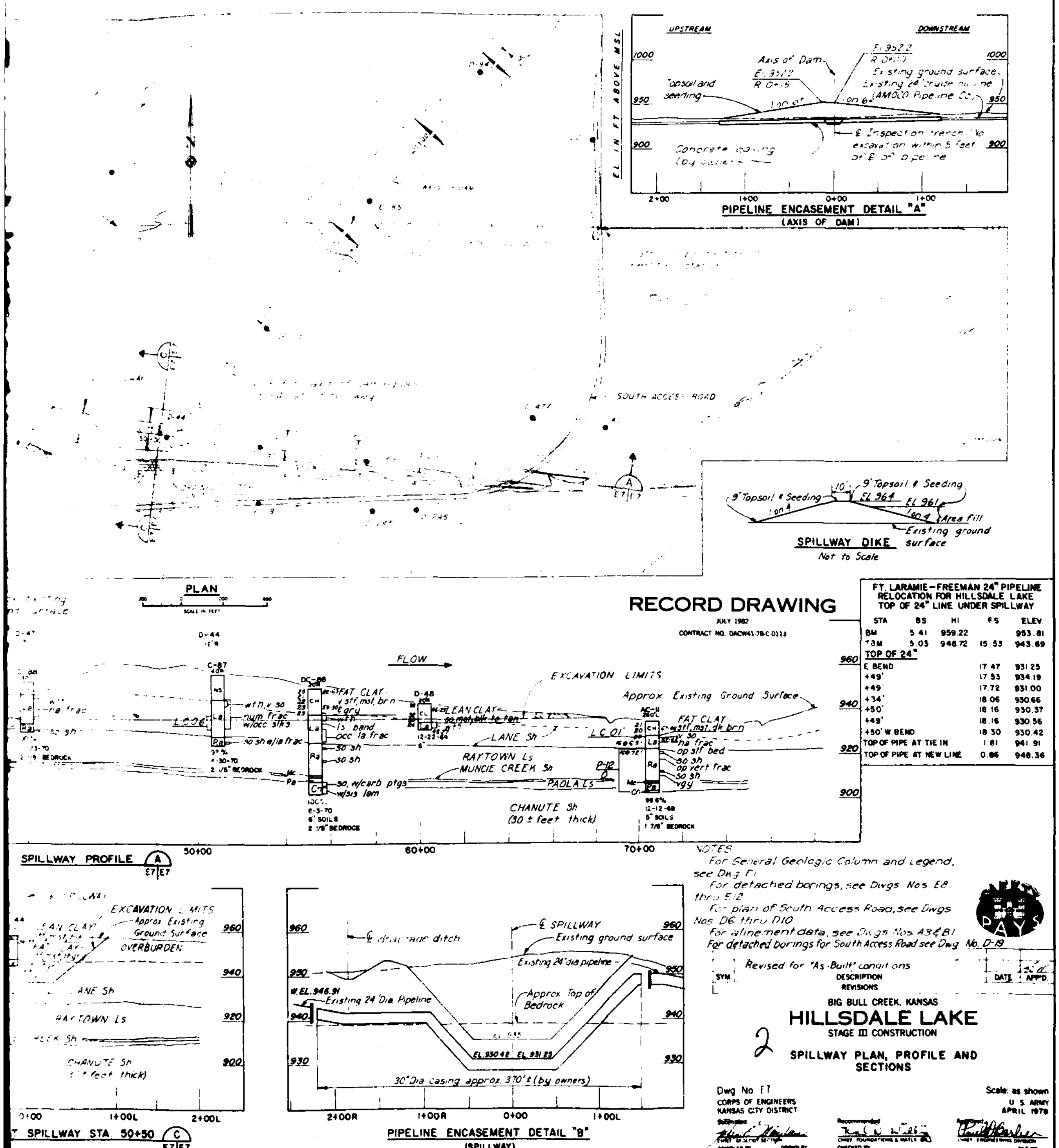

TYPICAL SLOPE INTERCEPTOR DITCH
TOE DITCH CONNECTION DETAIL
Not to scale
TYPICAL SLOPE INTERCEPTOR DITCH
TOE GUTTER CONNECTION DETAIL
Not to scale
Riprap slush grout in the interceptor and toe gutter ditches Radius will be set by contracting officer
Slope interceptor ditch
Start radius for lower ditch at Sta 111+00
Note
For embankment section at outlet works see Dwg No 88
Axis of dam
UPSTREAM
DOWNSTREAM
1/2" bituminous surface
Bituminous tack coat
Guardrail
6" crushed stone base course
3" bituminous base
Topsoil and Seeding
Slope varies
Random
Impervious
6' Pervious
TOP OF DAM DETAIL
Note
Top of dam width from turnaround to Sta 36+00 is 5' with aggregate surface
TOE GUTTER DITCH-4' TOE DITCH
CONNECTION DETAIL
Not to scale
Original ground surface
Strip as required
Random or Berm
3' Pervious
DOWNSTREAM EMBANKMENT TOE DETAIL B
Note
Use Detail B where Pervious drain extends to embankment toe
Note
From Station 75+00± to 116+00± the foundation inclined Pervious shall be connected to the horizontal Pervious See Dwg No 83
Embankment toe
Top of pervious
PLAN OF PERVIOUS DRAIN
SLOPE INTERCEPTOR DITCH DETAIL
TYPICAL
SECTION A
TYPICAL
SECTION B
RECORD DRAWING
Revised for As Built conditions
SYM
DESCRIPTION
REVISIONS
DATE
APP'D
BIG BULL CREEK KANSAS
HILLSDALE LAKE
STAGE I CONSTRUCTION
EMBANKMENT, SECTIONS AND DETAILS
Dwg No 85
CORPS OF ENGINEERS
KANSAS CITY DISTRICT
Scale as shown
U S ARMY
APRIL 1978
0-15-688

PLATE NO 14



PLAN
SPILLWAY PROFILE
ELEVATION IN FEET ABOVE MEAN SEA LEVEL
Approx Top of Bedrock
Approx Existing Ground Surface
TOPSOIL
FAT CLAY
OVERBURDEN
RAYTOWN Ls
MUNCIE CREEK Sh
PAOLA Ls
CHANUTE Sh
(30± feet thick)
LANE Sh
Pipeline Relocation by owners. See Detail "B"
D-431
D-432
D-45
D-46
D-47
DC-433
DC-434
C-89
C-90
C-88
C-474
D-91
20+00
30+00
40+00
50+00
60+00
960
940
920
900
SECTION AT SPILLWAY STA. 36+85
SECTION AT SPILLWAY STA. 50+50
PIPELINE ENCASEMENT DETAIL
EXCAVATION LIMITS
℄ SPILLWAY
LEAN CLAY w/sand & gravel
2+00R
1+00R
0+00
1+00L
2+00L



FT. LARAMIE–FREEMAN 24" PIPELINE RELOCATION FOR HILLSDALE LAKE
TOP OF 24" LINE UNDER SPILLWAY

STA	BS	HI	FS	ELEV.
BM	5.41	959.22		953.81
TBM	5.03	948.72	15.53	943.69
TOP OF 24"				
E. BEND			17.47	931.25
+49'			17.53	934.19
+49'			17.72	931.00
+34'			18.06	930.66
+50'			18.16	930.37
+49'			18.16	930.56
+50' W. BEND			18.30	930.42
TOP OF PIPE AT TIE IN			1.81	941.91
TOP OF PIPE AT NEW LINE			0.86	948.36

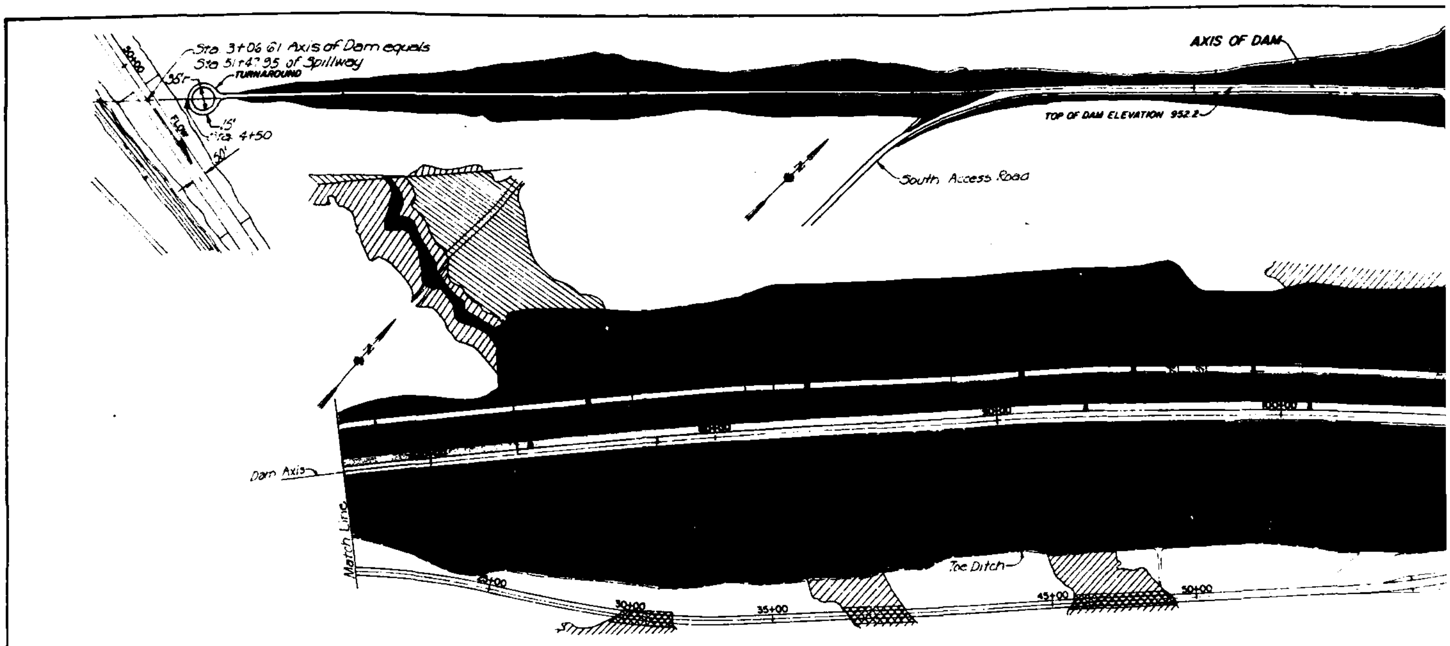
NOTES:
For General Geologic Column and Legend, see Dwg E1
For detached borings, see Dwgs Nos E8 thru E12
For plan of South Access Road, see Dwgs Nos D6 thru D10
For alinement data, see Dwgs Nos A3 & B1
For detached borings for South Access Road see Dwg No. D-19

Revised for "As-Built" conditions
SYM. DESCRIPTION DATE APP'D.
REVISIONS

BIG BULL CREEK, KANSAS
HILLSDALE LAKE
STAGE III CONSTRUCTION
2
SPILLWAY PLAN, PROFILE AND SECTIONS

Dwg No E7
CORPS OF ENGINEERS
KANSAS CITY DISTRICT
Scale: as shown
U. S. ARMY
APRIL 1978
Submitted: Chief, Geology Section
Recommended: Chief, Foundations & Materials Br.
Approved: Chief, Engineering Division
Compiled by: M L S
Drawn by: C R T
Checked by: J M M
File No: 0-15-732

PLATE NO 15



BEDDING, SPALLS, AND RIPRAP

SOURCE	LOCATION	GEOLOGIC UNIT
Killough, Inc. Qy. No. 04 (Bones) See Note 1	SW ¼, Sec. 27, T. 16 S., R. 22 E., Miami Co., Kans.	Spring Hill limestone

Note 1: Only the upper 14 feet acceptable for riprap.

Except for 12-inch riprap, stone for all other riprap shall not be placed during the period 1 November to 1 April unless supplied from free-draining stockpiles constructed at least 60 days prior to placement. Said stockpile material shall be tested for gradation and re-processed as necessary prior to delivery to the job site.

MATERIALS: Stone for riprap and bedding, except 24-inch, shall be sound, durable limestone free from cracks, seams, shale partings, and overburden spoil. The existing stockpiles of limestone in addition to materials from required excavation may be used for 24-inch limestone-shale slope protection and rock fill.

ELONGATION:

RIPRAP. Stone for riprap shall be approximately rectangular in cross section and be relatively free from thin slabby pieces having an elongation ratio greater than 3, except stone for 24-inch limestone-shale and rock fill. In no case shall the quantity of stone having an elongation ratio greater than 3 exceed 5 percent by weight of any one load or area.

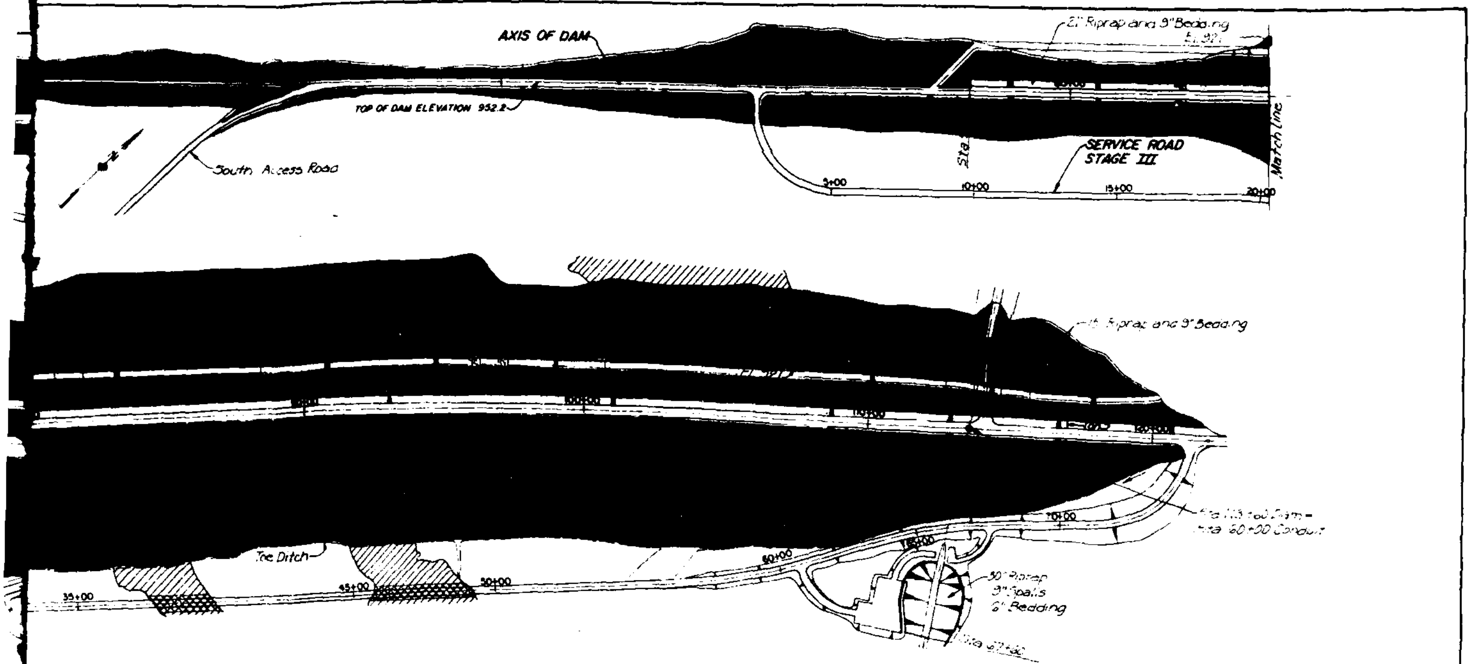
BEDDING AND SPALLS larger than the 1-inch standard sieve shall be reasonably free from flat, elongated particles.

DELETERIOUS SUBSTANCES which include soft friable particles, shale, objectionable materials, and other foreign matter shall not exceed 10 percent by weight.

WASHING: Type III bedding that is placed over the downstream end of the pervious drain shall be washed with either a log washer or a screw washer at the Contractor's option.

SIEVE SIZE	PERCENT BY WEIGHT PASSING
BEDDING (TYPE I)	
5-inch	Maximum Allowable
3-inch	75-95
1-inch	40-60
½-inch	20-40
#4	0-20
BEDDING (TYPE II)	
1-inch	Maximum Allowable
3/8-inch	75-95
#8	35-55
#16	20-40
#40	0-20
BEDDING (TYPE III)	
6-inch	Maximum Allowable
3-inch	70-90
1½-inch	55-75
½-inch	35-55
#4	15-35
#10	0-20
#20	0-5
SPALLS	
6-inch	Maximum Allowable
5-inch	75-95
2-inch	40-60
1-inch	20-40
½-inch	0-20

WEIGHT IN POUNDS PER STONE	PERCENT OF TOTAL WEIGHT LIGHTER THAN
12-INCH RIPRAP	
120#	100
60#	60-90
30#	30-50
5#	0-15
15-INCH RIPRAP	
200#	100
150#	60-90
50#	30-50
15#	0-10
21-INCH RIPRAP	
600#	100
300#	60-90
150#	30-50
50#	0-15
30-INCH RIPRAP	
1200#	100
900#	85-95
350#	30-50
75#	0-15



	PERCENT BY WEIGHT PASSING
G (TYPE I)	
	Maximum Allowable
	75-95
	40-60
	20-40
	0-20
G (TYPE II)	
	Maximum Allowable
	75-95
	35-55
	20-40
	0-20
G (TYPE III)	
	Maximum Allowable
	70-90
	55-75
	35-55
	15-35
	0-20
	0-5
ALLS	
	Maximum Allowable
	75-95
	40-60
	20-40
	0-20

WEIGHT IN POUNDS PER STONE	PERCENT OF TOTAL WEIGHT LIGHTER THAN
12-INCH RIPRAP	
120#	100
60#	60-90
30#	30-50
5#	0-15
15-INCH RIPRAP	
200#	100
150#	60-90
50#	30-50
15#	0-10
21-INCH RIPRAP	
600#	100
300#	60-90
150#	30-50
50#	0-15
30-INCH RIPRAP	
1200#	100
900#	85-95
350#	30-50
75#	0-15

LEGEND

24" LIMESTONE AND SHALE
12" RIPRAP AND 6" BEDDING
15" RIPRAP AND 9" BEDDING
21" RIPRAP AND 9" BEDDING
30" RIPRAP, 9" SPALLS, AND 6" BEDDING
STONE PROTECTION FOR CLAY BLANKET, REMEDIAL WORK
SEEDED

Revisions			
Symbol	Descriptions	Date	Approved

U. S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
KANSAS CITY, MISSOURI

Designed by:
Drawn by:
Checked by:
Submitted by:

US Army Corps of Engineers

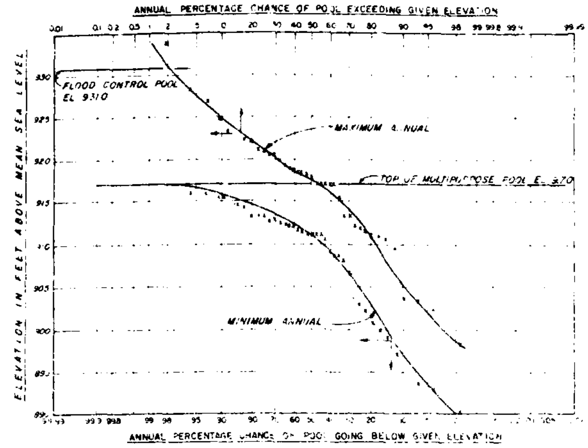
BIG BULL CREEK, KANSAS
HILLSDALE LAKE
EMBANKMENT CRITERIA REPORT

SLOPE PROTECTION PLAN

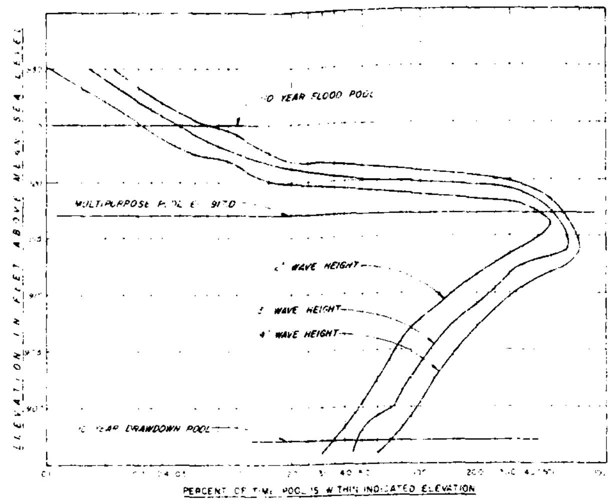
Scale:
Sheet number: 1 of 1
Date: SEPTEMBER 1984
Dwg. No.:
File No. 0-15-1061

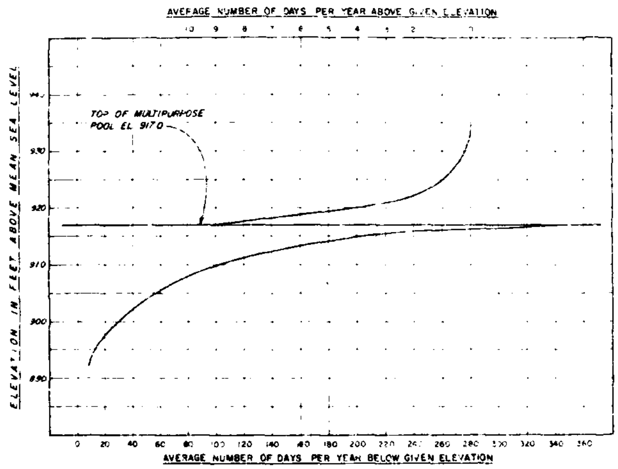
2

PLATE NO. 16



POOL ELEVATION - EXCEEDANCE FREQUENCY CURVE

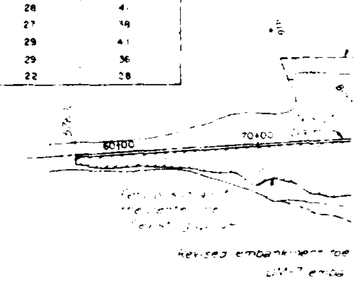


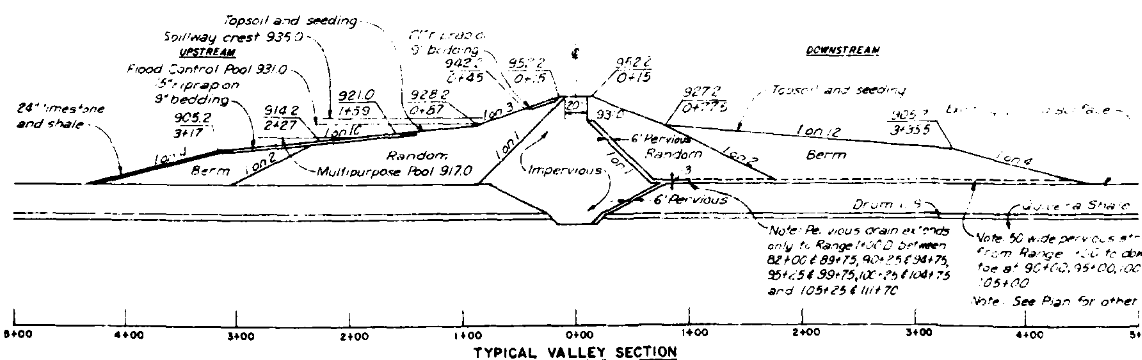


POOL ELEVATION - DURATION CURVE

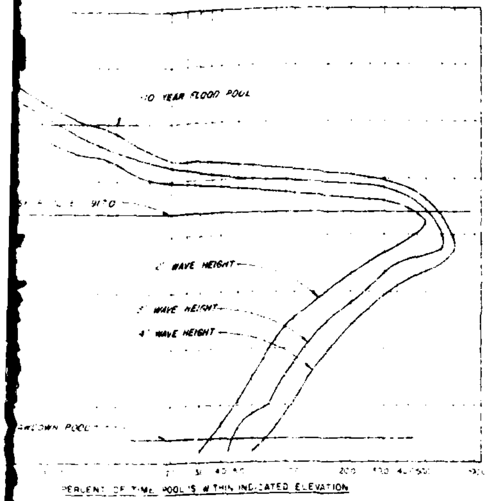
WIND VELOCITY - FREQUENCY CHART					
DIRECTION	FREQUENCY* YEARS	TOPEKA, KS M.P.H.	COLUMBIA, MO M.P.H.	KANSAS CITY, MO M.P.H.	DESIGN WIND M.P.H.
N	100	54	36	28	36
NW	100	45	49	31	49
NNW	100		45	3	45
WNW	100	46	49	34	49
W	100	42	45	33	43
NE	100	37	32	25	32
N	50	52	35	27	35
NW	50	44	47	30	47
NNW	50		43	30	43
WNW	50	44	47	33	47
W	50	47	41	32	41
NE	50	36	32	24	32
N	10	45	31	25	31
NW	10	40	41	28	41
NNW	10		38	27	38
WNW	10	40	41	29	41
W	10	40	36	29	36
NE	10	33	28	22	28

* AVERAGE HOURLY WIND





TYPICAL VALLEY SECTION



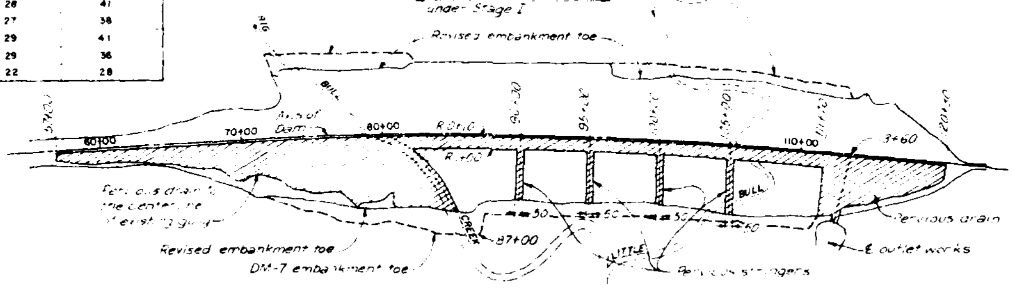
RIPRAP STUDY (SPECIFIC GRAVITY = 2.60)																
LOCATION			FETCH		WIND		WAVE				RIPRAP					
STA	ELEV	SLOPE	LENGTH	DIRECT	FREQ (YR)	SPEED (MPH)	H_s	H_D	$1.5 \times H_D$	TYPE	W_R SF=1.0	W_R SF=1.3	W_R PROP	THICK	S.F.
POINT "A"															
70+00	931	1 ON 3	2.34	NW	100	49	3.5	4.9	6.4	DW	200	446	200	24"	1.00
70+00	917	1 ON 10	1.65	NW	100	49	3.0	4.2	5.5	DW	24	52	50	15"	1.3
70+00	917	1 ON 3	1.85	NW	100	49	3.0	4.2	5.5	DW	126	283	150	21"	1.06
70+00	931	1 ON 3	2.34	NW	50	47	3.0	4.2	5.5	DW	122	274	150	21"	1.07
70+00	917	1 ON 10	1.85	NW	50	47	2.7	3.8	4.9	DW	20	46	50	15"	1.4
70+00	917	1 ON 3	1.85	NW	50	47	2.7	3.8	4.9	DW	91	194	100	18"	1.03
70+00	931	1 ON 3	2.34	NW	10	41	2.6	3.5	4.7	DW	77	171	100	18"	1.09
70+00	917	1 ON 10	1.85	NW	10	41	2.4	3.4	4.4	DW	14	29	30	12"	1.3
70+00	917	1 ON 3	1.85	NW	10	41	2.4	3.4	4.4	DW	65	141	100	18"	1.15
POINT "B"															
90+00	931	1 ON 3	2.38	NW	100	49	3.5	4.9	6.4	DW	200	446	200	24"	1.00
90+00	917	1 ON 10	1.82	NW	100	49	3.0	4.2	5.5	DW	24	52	50	15"	1.3
90+00	917	1 ON 3	1.82	NW	100	49	3.0	4.2	5.5	DW	126	283	150	21"	1.06
90+00	931	1 ON 3	2.38	NW	50	47	3.0	4.2	5.5	DW	122	274	150	21"	1.07
90+00	917	1 ON 10	1.82	NW	50	47	2.7	3.8	4.9	DW	20	45	50	15"	1.4
90+00	917	1 ON 3	1.82	NW	50	47	2.7	3.8	4.9	DW	91	194	100	18"	1.03
90+00	931	1 ON 3	2.38	NW	10	41	2.6	3.6	4.7	DW	77	171	100	18"	1.09
90+00	917	1 ON 10	1.82	NW	10	41	2.4	3.4	4.4	DW	14	29	30	12"	1.3
90+00	917	1 ON 3	1.82	NW	10	41	2.4	3.4	4.4	DW	65	141	100	18"	1.15
POINT "C"															
115+00	931	1 ON 3	2.40	WNW	100	49	3.5	4.9	6.4	DW	200	446	200	24"	1.00
115+00	917	1 ON 8	1.93	WNW	100	49	3.0	4.2	5.5	DW	26	58	50	15"	1.2
115+00	917	1 ON 3	1.93	WNW	100	49	3.0	4.2	5.5	DW	126	283	150	21"	1.06
115+00	931	1 ON 3	2.40	WNW	50	47	3.0	4.2	5.5	DW	122	274	150	21"	1.07
115+00	917	1 ON 8	1.93	WNW	50	47	2.7	3.8	4.9	DW	19	41	50	15"	1.4
115+00	917	1 ON 3	1.93	WNW	50	47	2.7	3.8	4.9	DW	91	194	100	18"	1.03
115+00	931	1 ON 3	2.40	WNW	10	41	2.6	3.6	4.7	DW	77	171	100	18"	1.09
115+00	917	1 ON 8	1.93	WNW	10	41	2.4	3.4	4.4	DW	14	30	30	12"	1.3
115+00	917	1 ON 3	1.93	WNW	10	41	2.4	3.4	4.4	DW	65	141	100	18"	1.15

NOTE: FETCH LENGTH IN MILES. DW = DEEP WATER

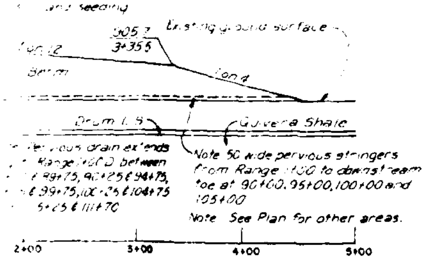
REFERENCE: CRITERIA FOR RIPRAP WAVE PROTECTION IN MRD, JUNE 1974

WIND VELOCITY - FREQUENCY CHART				
FREQUENCY YEARS	TOPEKA, KS. M.P.H.	COLUMBIA, MO M.P.H.	KANSAS CITY, MO M.P.H.	DESIGN WIND M.P.H.
[illegible]	5[illegible]	36	28	36
100	45	49	31	49
100		45	3	45
100	46	49	34	49
100	49	43	33	43
100	37	32	25	32
50	52	35	27	35
50	44	47	30	47
50		43	30	43
50	44	47	33	47
50	47	41	32	41
50	36	32	24	32
10	45	31	25	31
10	40	41	28	41
10		38	27	38
10	40	41	29	41
10	40	36	29	36
10	33	28	22	28

...LY WIND



PLAN OF PERVIOUS DRAIN



Note 50' wide pervious stringers from Range 1+00 to downstream toe at 90+00, 95+00, 100+00 and 105+00.

Note: See Plan for other areas.

SYM.	DESCRIPTION	DATE	APP'D
	REVISIONS		

BIG BULL CREEK, KANSAS

HILLSDALE LAKE

EMBANKMENT CRITERIA REPORT

2 RIPRAP DESIGN, TYPICAL VALLEY EMBANKMENT AND PLAN OF PERVIOUS DRAIN

In 1 sheet. Sheet No. 1. Scale: as shown

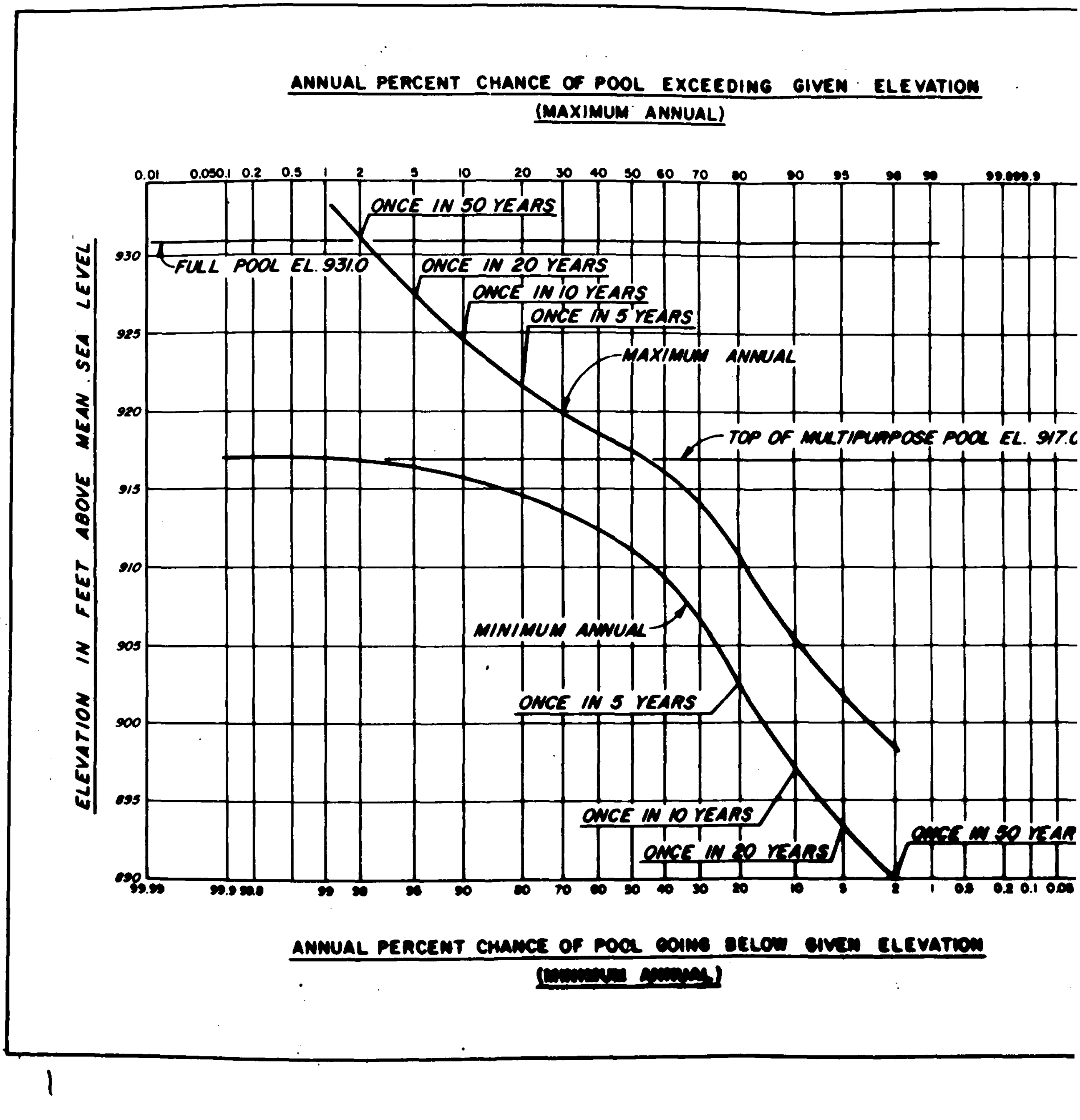
CORPS OF ENGINEERS, KANSAS CITY DISTRICT. U.S. ARMY. JANUARY 1978

Submitted / Recommended / Approved

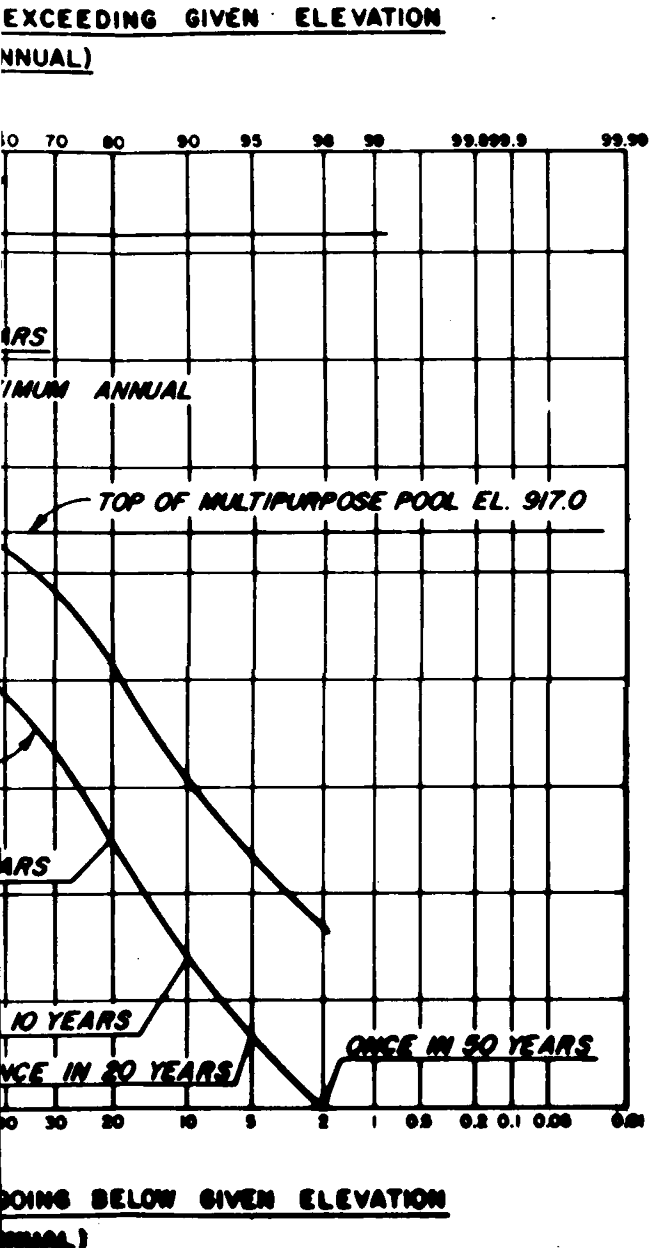
COMPILED BY GAD. DRAWN BY JPM. CHECKED BY RGF.

DM-7 0-15-678

SUPPLEMENT A PLATE NO. 17



ANNUAL PERCENT CHANCE OF POOL EXCEEDING GIVEN ELEVATION
(MAXIMUM ANNUAL)
ELEVATION IN FEET ABOVE MEAN SEA LEVEL
FULL POOL EL. 931.0
ONCE IN 50 YEARS
ONCE IN 20 YEARS
ONCE IN 10 YEARS
ONCE IN 5 YEARS
MAXIMUM ANNUAL
TOP OF MULTIPURPOSE POOL EL. 917.0
MINIMUM ANNUAL
ONCE IN 5 YEARS
ONCE IN 10 YEARS
ONCE IN 20 YEARS
ONCE IN 50 YEAR
ANNUAL PERCENT CHANCE OF POOL GOING BELOW GIVEN ELEVATION
(MINIMUM ANNUAL)



SYM.	DESCRIPTION	DATE	APP'D.
	REVISIONS		

BIG BULL CREEK, KANSAS

HILLSDALE LAKE

MASTER PLAN

LAKE STAGE FREQUENCY CURVES

In 1 sheet. Sheet No. 1 Scale: as shown

CORPS OF ENGINEERS U. S. ARMY

KANSAS CITY DISTRICT FEBRUARY 1978

Approved:

CHIEF, ENGINEERING DIV.

COMPILED BY: R.L.T. DRAWN BY: J.P.M. CHECKED BY: APB FILE NO. 0-15-613

2

PLATE NO. 17A

GENERALIZED GEOLOGIC COLUMN

SYSTEM	GROUP	FORMATION	MEMBER	SYMBOL	APPROXIMATE THICKNESS	GENERAL DESCRIPTION
PENNSYLVANIAN	LANSING	PLATTSBURG	Spring Hill	Sp	14'	LIMESTONE: moderately hard, dense to occasionally very finely crystalline, with occasional [illegible], thin bedded to massive with shaly partings, light grey
			Hickory Creek	Hc	0.5'	SHALE: soft, platy, calcareous, dark grey
			Merriam	Me	2.5'	LIMESTONE: moderately hard, dense to occasionally very finely crystalline, oolitic, fossiliferous, thin bedded, light grey
	KANSAS CITY	Bonner Springs		Bs	19'	SHALE: soft to very soft, platy, calcareous partings [illegible] dark grey with maroon zone in center part, moderately hard, very fine grained sandstone at bottom
		WYANDOTTE	Farley and Argentine	Fa Ar	14'	LIMESTONE: moderately hard, dense, thin bedded with wavy shale partings, light grey to buff with light blue mottling
		Lane		La	100'	SHALE: soft to occasionally very soft, clayey to sandy, platy, grey to dark grey, with occasional carbonaceous partings and limestone nodules; upper half of formation [illegible] sandstone, moderately hard, fine grained, micaceous, occasionally calcareous, thin bedded, grey
		IOLA	Raytown	Ra	[illegible]	LIMESTONE: moderately hard, dense to finely crystalline, argillaceous and fossiliferous, thin to medium wavy bedded, light [illegible]; shale separates member [illegible] limestone units; shale [illegible] soft, clayey, platy, dark grey
			Muncie Creek	Mc	0.5'	SHALE: soft, clayey, platy, calcareous, occasional [illegible] phosphatic nodules, grey
			Paola	Pa	2.5'	LIMESTONE: moderately hard, dense, fossiliferous, thick bedded, light grey
		Chanute		Ch	30'	SHALE, SANDSTONE AND SILTSTONE: [illegible] with sandstone and siltstone common in upper half of formation; shale is soft to moderately hard, clayey to silty, platy to massive, occasionally calcareous, [illegible] with [illegible] limestone nodules in lower portion of formation; [illegible] sandstone [illegible] is moderately hard, very fine grained, [illegible] thin bedded; grey siltstone often interlaminated with shale
		Drum		Dr	4'	LIMESTONE: moderately hard, dense to very finely crystalline, thin to medium bedded, numerous [illegible] shale partings, fossiliferous, light grey
		CHERRYVALE	Quivira	Qu	[illegible]	SHALE AND SILTSTONE: shale is soft, clayey to silty, platy, dark grey; shale [illegible] with occasional very [illegible] partings and bands [illegible] common [illegible] the upper 4 feet of the member; in lower portion of member the shale is often interlaminated with moderately hard light grey siltstone
			Westerville	We	2.5'	LIMESTONE: moderately hard, thin bedded, dense, argillaceous, bluish grey limestone with green shaly partings and bands, varying to a nodular limestone in a green shale matrix
			Wea	Wa	21'	SHALE: soft to moderately hard, clayey to silty, platy, occasionally calcareous and siltstone partings, dark grey to green grey
			Block	B	14'	LIMESTONE: moderately hard, dense to very finely crystalline, thin wavy bedding, light brownish grey with occasional light blue mottling, with numerous dark grey soft shale partings to beds
			Fontana	Fn	14'	SHALE: soft to moderately hard, clayey to silty, platy, dark grey to green grey with occasional siltstone partings
		DENNIS	Winterset	Wi	Cored 5'	LIMESTONE: moderately hard to hard, very finely crystalline, argillaceous, thick bedded, light grey

NOTE: A vertical joint system consisting of two prominent sets, commonly occurring in the area, is found in all bedrock units at the dam site. Where the bedrock surface consists of limestone, these joints have been widened to varying degrees by solutioning and weathering processes. These processes have also been active along bedding planes in near-surface limestones. The resulting solution cavities are partially or completely filled with fine grained soils and occasional rock fragments. In the dam abutments, this solutioning activity may be found some distance back from the valley walls even though the limestone is overlain by shale.

ABBREVIATIONS [illegible]

UNIFIED SOIL CLASSIFICATION SYSTEM

[illegible] May 1967

BEDROCK

BEDROCK UNIT THICKNESS

SECTION IDENTIFICA

ABBREVIATIONS

LEGEND FOR LOGS OF BORINGS

Plasticity index

Liquid limit

Moisture content, percent

Piezometer

Permanent Piezometer

TYPE OF EXPLORATION

MAP SYMBOL

CODE DESIGNATION

UNIFIED SOIL CLASSIFICATION SYSTEM

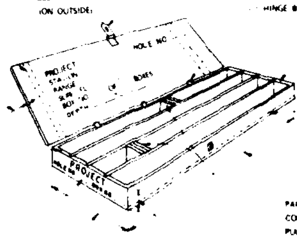
TERMS FOR CONSISTENCY OF SOIL AND HARDNESS OF BEDROCK

SOIL

BEDROCK

SCALE OF HARDNESS

BEDROCK UNIT THICKNESS



NOTE

LABELS FOR CORE BOX WILL BE PLACED ON OUTSIDE AND INSIDE OF COVER AND OUTSIDE ON EACH END

CORE BOX DETAILS

(FOR EXPLORATORY DRILLING)

SECTION IDENTIFICATION

RECORD DRAWING

DECEMBER 1977

CONTRACT NO. DACW41 76-C-0115

SYM	DESCRIPTION	DATE	APP'D
	Revised for "As Built" conditions	4-28-78	

REVISIONS

BIG BULL CREEK, KANSAS

HILLSDALE LAKE

STAGE I CONSTRUCTION

2

GENERAL GEOLOGIC COLUMN AND LEGEND

Dwg No. 5

CORPS OF ENGINEERS
KANSAS CITY DISTRICT

Scale: as shown
U. S. ARMY
FEBRUARY 1976

Submitted: CHIEF, GEOLOGY SECTION

Recommended: CHIEF, FOUNDATIONS & MATLS. BR.

Approved: CHIEF, ENGINEERING DIVISION

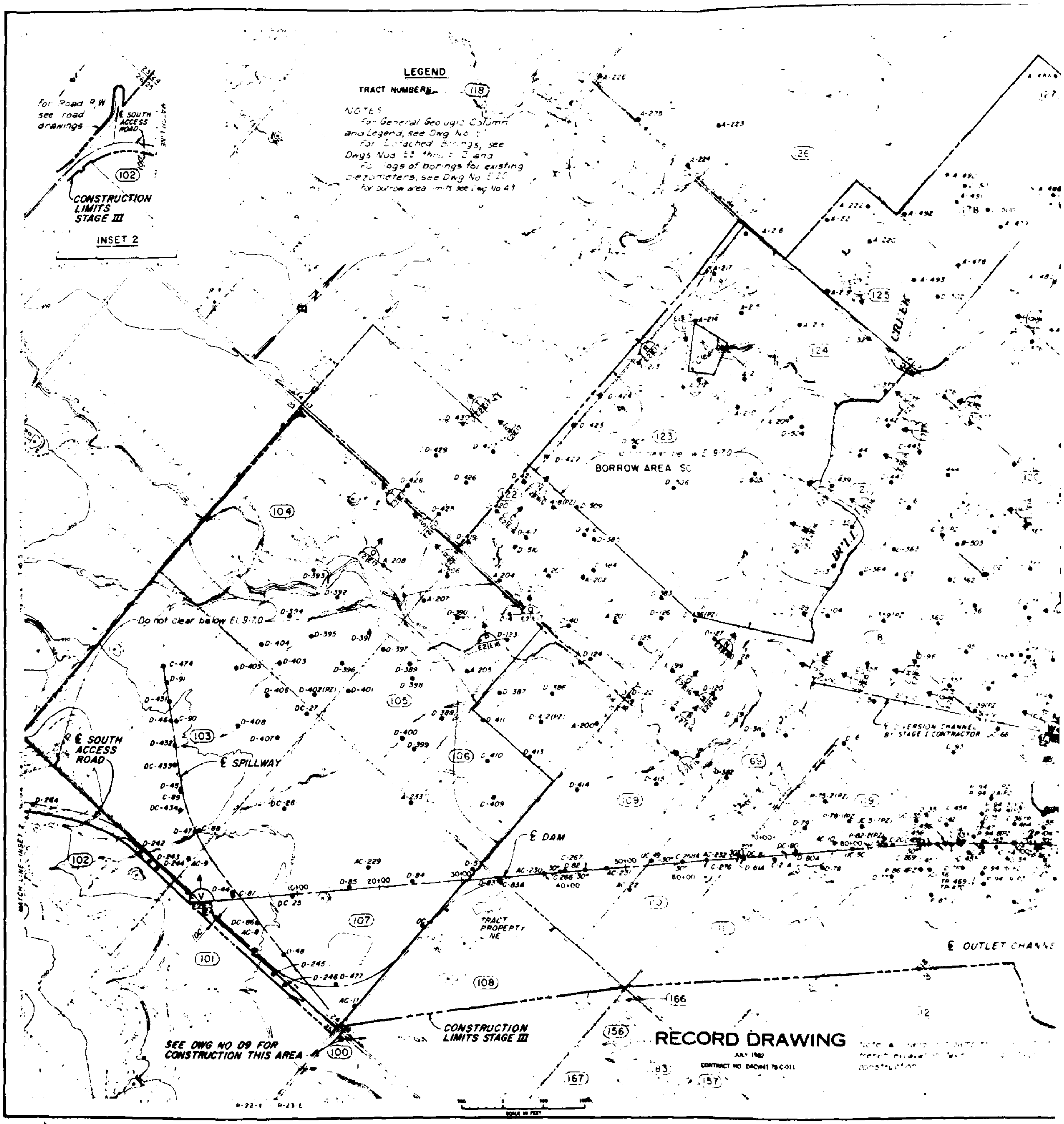
COMPILED BY R G S

DRAWN BY G W D

CHECKED BY R G S

FILE NO. 0-15-465

PLATE NO 18


LEGEND
TRACT NUMBERS
118
NOTES
For Road R.W. see road drawings
SOUTH ACCESS ROAD
CONSTRUCTION LIMITS STAGE III
INSET 2
BORROW AREA SC
Do not clear below El. 970
℄ SOUTH ACCESS ROAD
℄ SPILLWAY
℄ DAM
TRACT PROPERTY LINE
CONSTRUCTION LIMITS STAGE III
SEE DWG NO 09 FOR CONSTRUCTION THIS AREA
RECORD DRAWING
JULY 1980
CONTRACT NO DACW41 78 C 011
CREEK
℄ OUTLET CHANNE
SCALE IN FEET

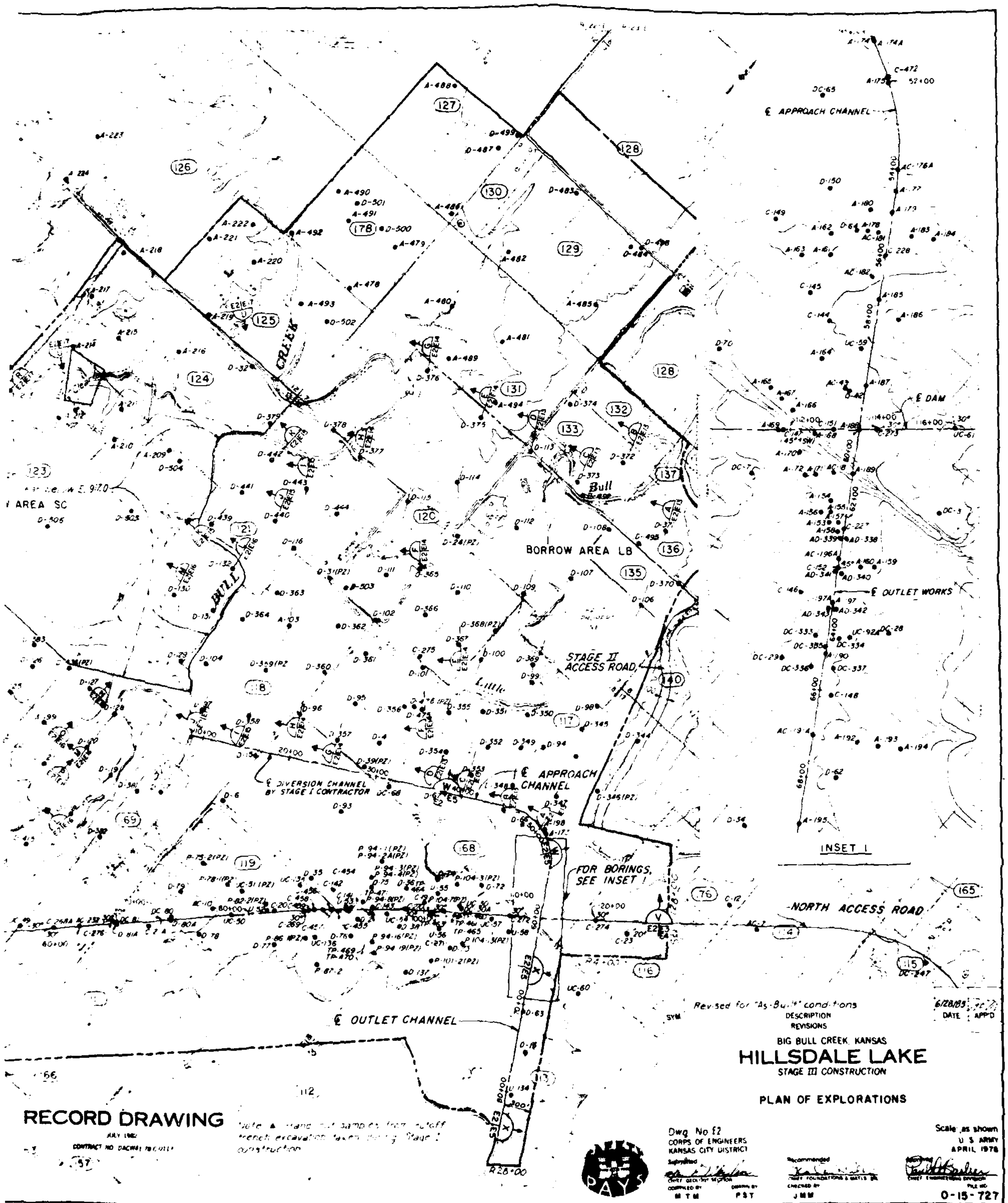
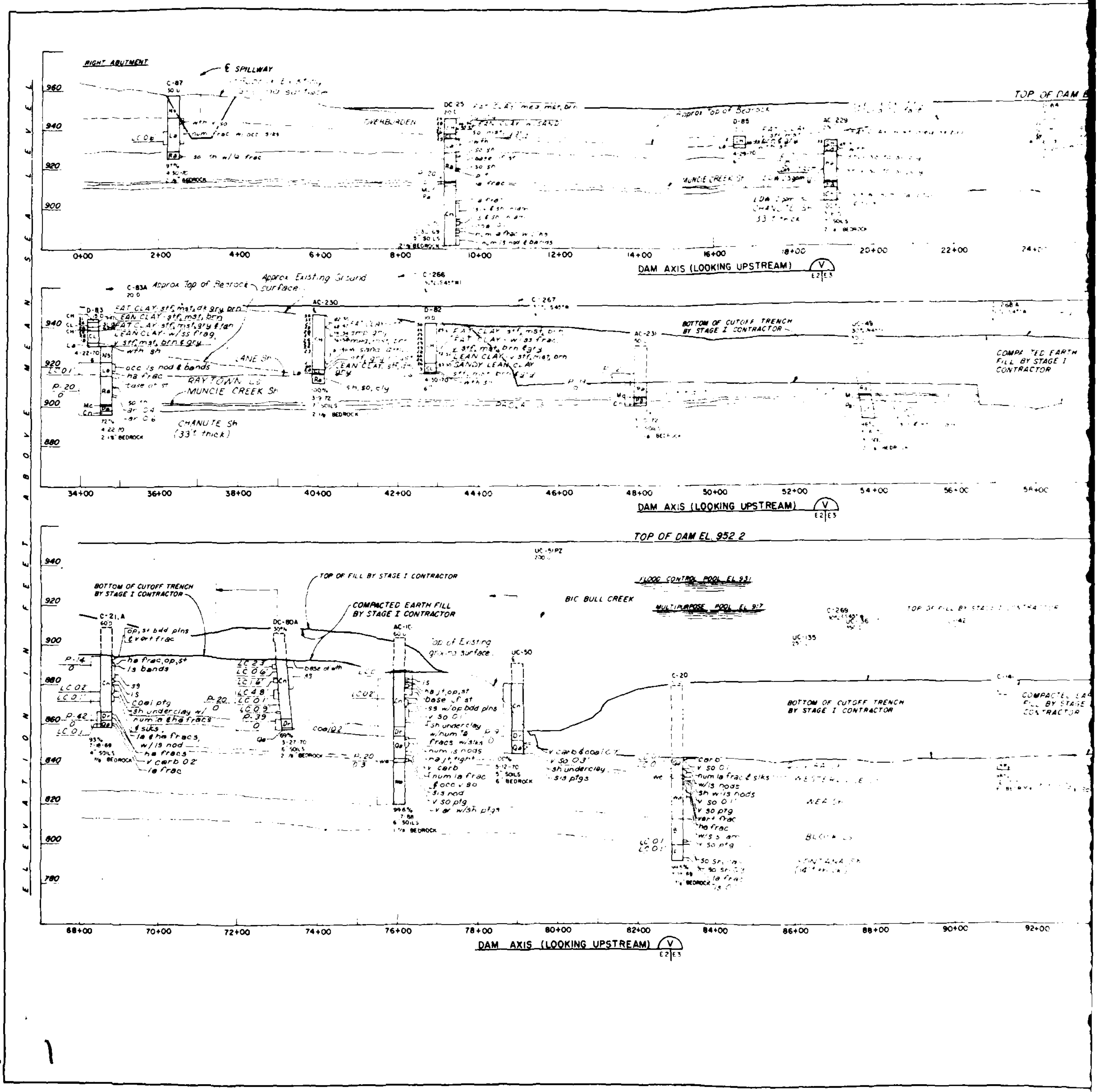
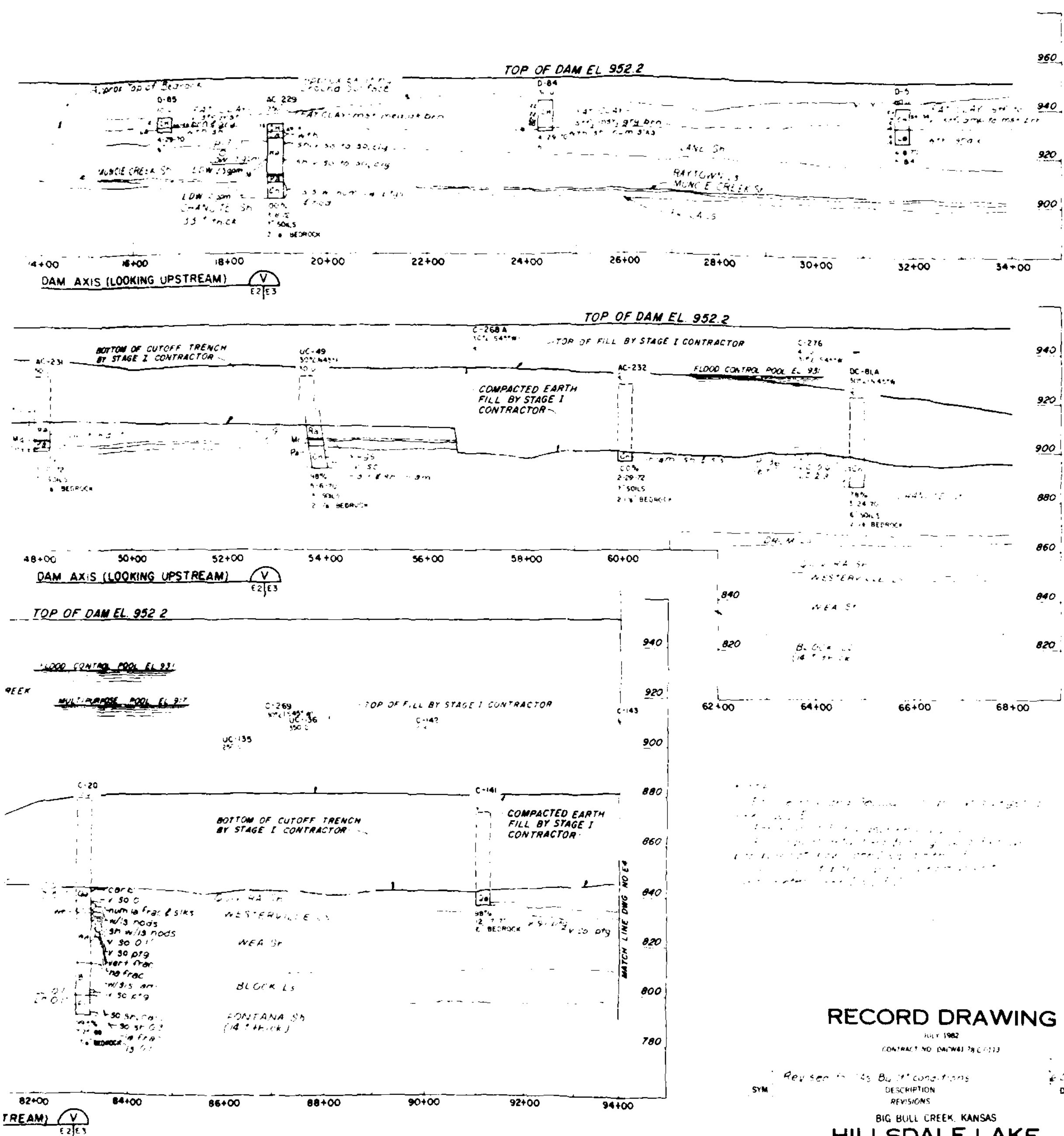

BORROW AREA LB
STAGE II ACCESS ROAD
℄ APPROACH CHANNEL
℄ DIVERSION CHANNEL BY STAGE I CONTRACTOR
FOR BORINGS, SEE INSET I
NORTH ACCESS ROAD
℄ OUTLET CHANNEL
℄ APPROACH CHANNEL
℄ DAM
℄ OUTLET WORKS
INSET I
BULL CREEK
RECORD DRAWING
Revised for "As-Built" conditions
DESCRIPTION
REVISIONS
DATE
APP'D
BIG BULL CREEK, KANSAS
HILLSDALE LAKE
STAGE III CONSTRUCTION
PLAN OF EXPLORATIONS
Dwg. No E2
CORPS OF ENGINEERS
KANSAS CITY DISTRICT
Scale as shown
U. S. ARMY
APRIL 1978
0-15-727

PLATE NO 19


RIGHT ABUTMENT
℄ SPILLWAY
TOP OF DAM
OVERBURDEN
Approx Top of Bedrock
MUNCIE CREEK Sh
CHANUTE Sh
DAM AXIS (LOOKING UPSTREAM)
Approx Top of Bedrock
Approx Existing Ground surface
FAT CLAY-stf, mst, dk gry brn
LEAN CLAY-stf, mst, brn
LEAN CLAY-w/ss frag
RAYTOWN LS
MUNCIE CREEK Sh
CHANUTE Sh (33'± thick)
BOTTOM OF CUTOFF TRENCH BY STAGE I CONTRACTOR
COMPACTED EARTH FILL BY STAGE I CONTRACTOR
DAM AXIS (LOOKING UPSTREAM)
TOP OF DAM EL. 952.2
BOTTOM OF CUTOFF TRENCH BY STAGE I CONTRACTOR
TOP OF FILL BY STAGE I CONTRACTOR
COMPACTED EARTH FILL BY STAGE I CONTRACTOR
Top of Existing ground surface
FLOOD CONTROL POOL EL 931
BIG BULL CREEK
MULTIPURPOSE POOL EL 917
BOTTOM OF CUTOFF TRENCH BY STAGE I CONTRACTOR
DAM AXIS (LOOKING UPSTREAM)
ELEVATION IN FEET ABOVE MEAN SEA LEVEL



RECORD DRAWING

JULY 1982

Revised to "As Built" conditions

SYM DESCRIPTION DATE APP'D

REVISIONS

BIG BULL CREEK, KANSAS

HILLSDALE LAKE

STAGE III CONSTRUCTION

LOGS OF SELECTED EXPLORATIONS
DAM AXIS

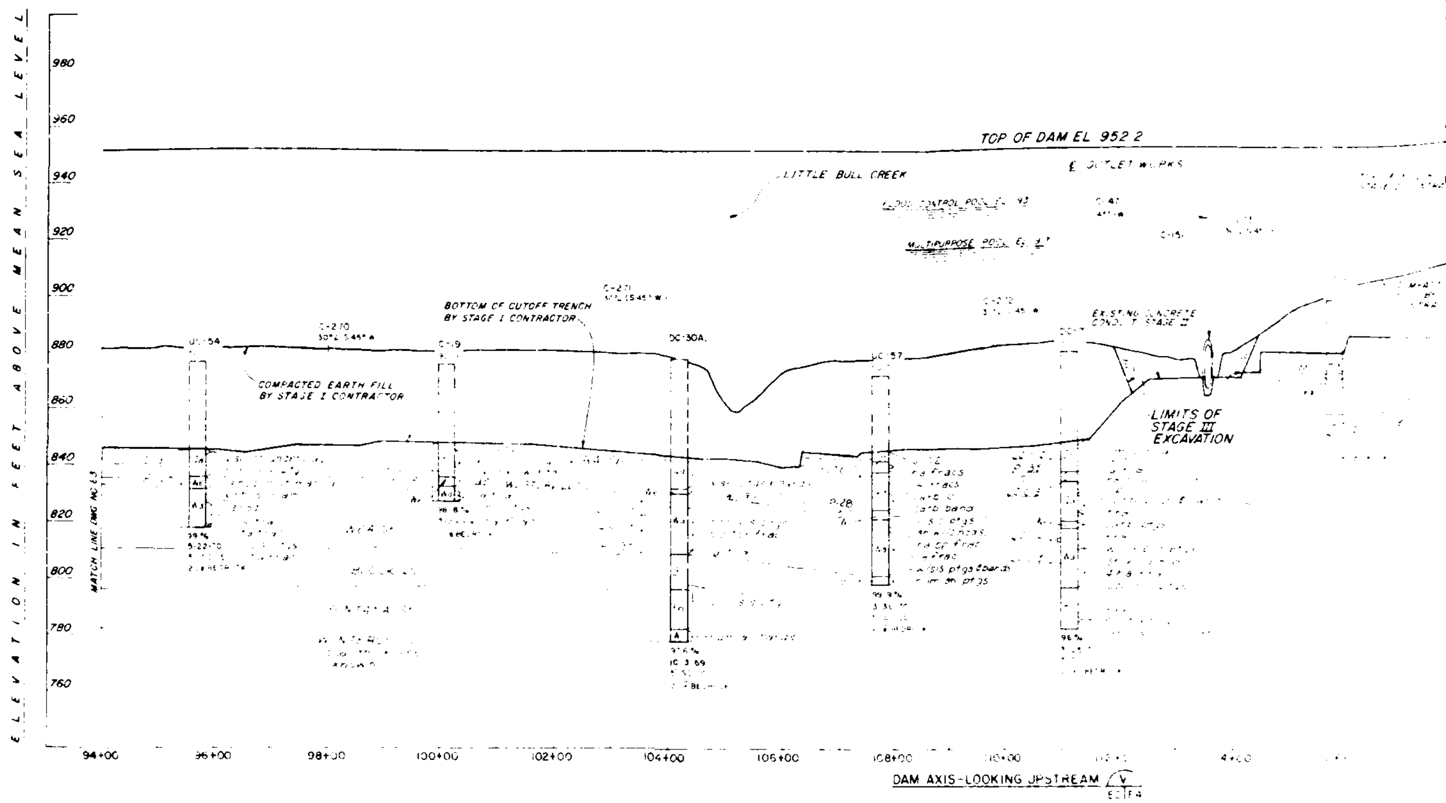
Dwg. No. E3
CORPS OF ENGINEERS
KANSAS CITY DISTRICT

Scale as shown
U.S. ARMY
APRIL 1978

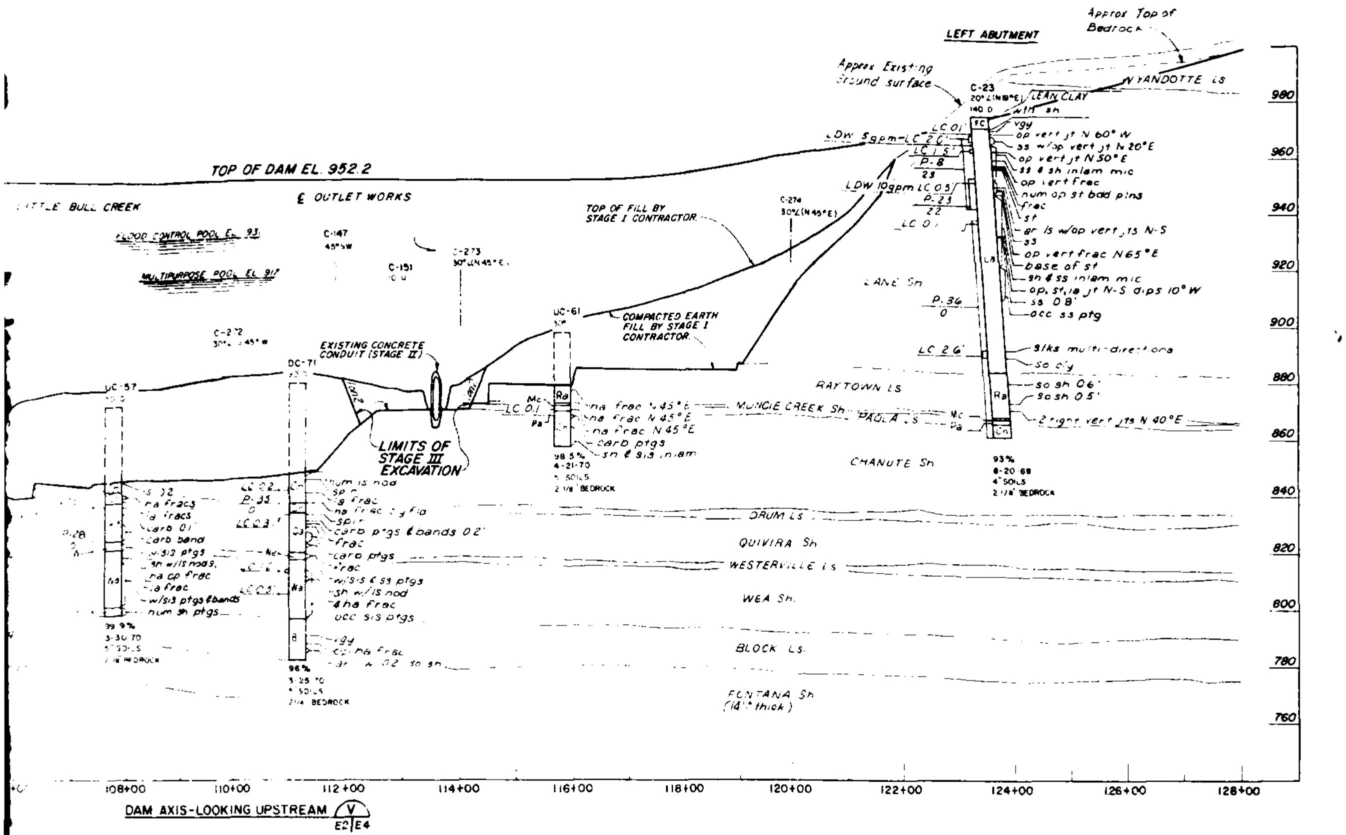
RGS RLD JMM

0-15-728

PLATE NO 20



ELEVATION IN FEET ABOVE MEAN SEA LEVEL
980
960
940
920
900
880
860
840
820
800
780
760
TOP OF DAM EL 952 2
LITTLE BULL CREEK
MULTIPURPOSE POOL
BOTTOM OF CUTOFF TRENCH BY STAGE I CONTRACTOR
COMPACTED EARTH FILL BY STAGE I CONTRACTOR
DC-30A
EXISTING CONCRETE CONDUIT STAGE II
LIMITS OF STAGE III EXCAVATION
MATCH LINE DWG NO 13
94+00
96+00
98+00
100+00
102+00
104+00
106+00
108+00
110+00
DAM AXIS-LOOKING UPSTREAM



NOTES:
For General Geologic Column and Legend, see Dwg. E1
For plan of borings, see Dwg. E2
For logs of borings for permanent piezometers, see Dwg. E20
For logs of detached borings and dam axis borings not shown see Dwgs E6 thru E12

RECORD DRAWING

JULY 1982

CONTRACT NO. DACW41 78 C 0113

SYM	DESCRIPTION	DATE	APP'D
	Revised for "As Built" conditions	6/28/83	

REVISIONS

BIG BULL CREEK, KANSAS

HILLSDALE LAKE

STAGE III CONSTRUCTION

LOGS OF SELECTED EXPLORATIONS
DAM AXIS

2

Dwg No E4
CORPS OF ENGINEERS
KANSAS CITY DISTRICT

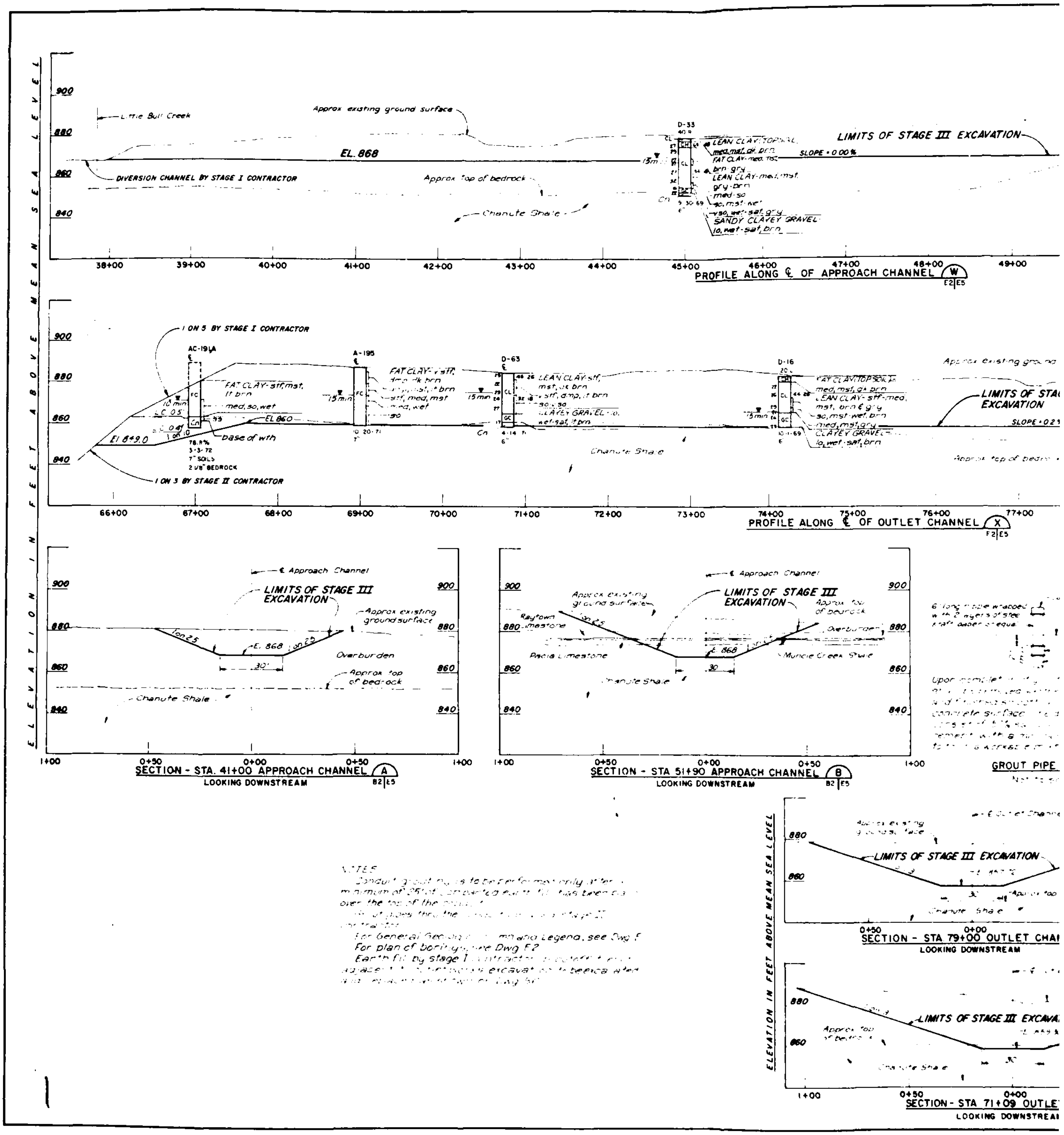
Scale as shown
U. S. ARMY
APRIL 1978

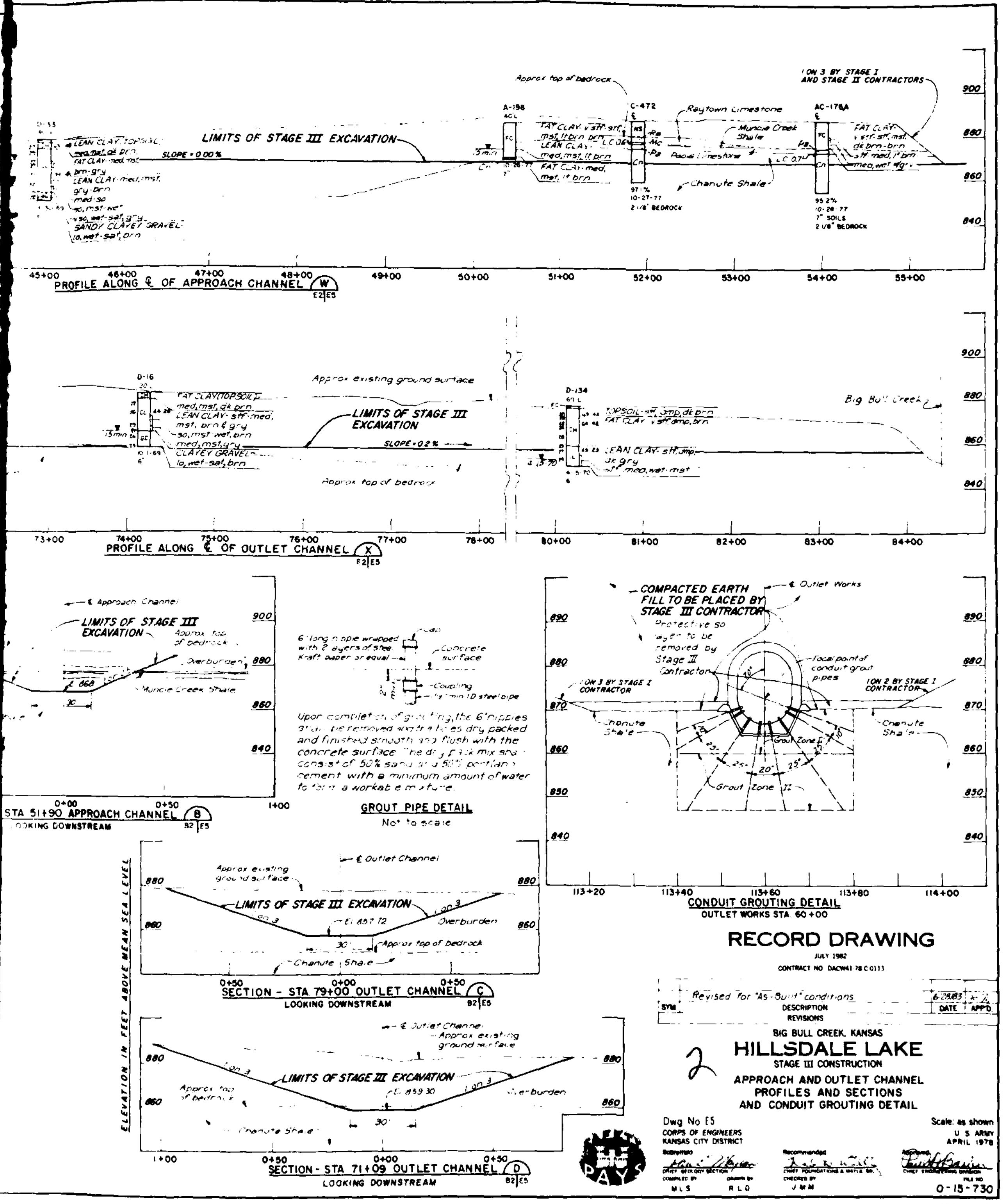
Submitted / Recommended / Approved

COMPILED BY R G S — DRAWN BY R L D — CHECKED BY J M M

FILE NO. 0-15-729

PLATE NO 21


ELEVATION IN FEET ABOVE MEAN SEA LEVEL
Little Bull Creek
Approx existing ground surface
EL. 868
DIVERSION CHANNEL BY STAGE I CONTRACTOR
Approx top of bedrock
Chanute Shale
LIMITS OF STAGE III EXCAVATION
SLOPE = 0.00%
LEAN CLAY
FAT CLAY
SANDY CLAYEY GRAVEL
PROFILE ALONG ℄ OF APPROACH CHANNEL W
1 ON 5 BY STAGE I CONTRACTOR
1 ON 3 BY STAGE II CONTRACTOR
base of wth
EL 860
El 849.0
CLAYEY GRAVEL
PROFILE ALONG ℄ OF OUTLET CHANNEL X
℄ Approach Channel
Approx existing ground surface
Overburden
Approx top of bedrock
SECTION - STA. 41+00 APPROACH CHANNEL A
LOOKING DOWNSTREAM
Raytown Limestone
Paola Limestone
Muncie Creek Shale
SECTION - STA 51+90 APPROACH CHANNEL B
LOOKING DOWNSTREAM
GROUT PIPE
NOTES
For General Geology ... and Legend, see Dwg F
For plan of borings, see Dwg F2
SECTION - STA 79+00 OUTLET CHA
LOOKING DOWNSTREAM
SECTION - STA 71+09 OUTLE
LOOKING DOWNSTREA



RECORD DRAWING

JULY 1982

CONTRACT NO DACW41-78-C-0113

SYM	DESCRIPTION	DATE	APP'D
2	Revised for "As-Built" conditions	6-28-83	

REVISIONS

BIG BULL CREEK, KANSAS

HILLSDALE LAKE

STAGE III CONSTRUCTION

APPROACH AND OUTLET CHANNEL PROFILES AND SECTIONS AND CONDUIT GROUTING DETAIL

Dwg No E5

CORPS OF ENGINEERS KANSAS CITY DISTRICT

Scale: as shown

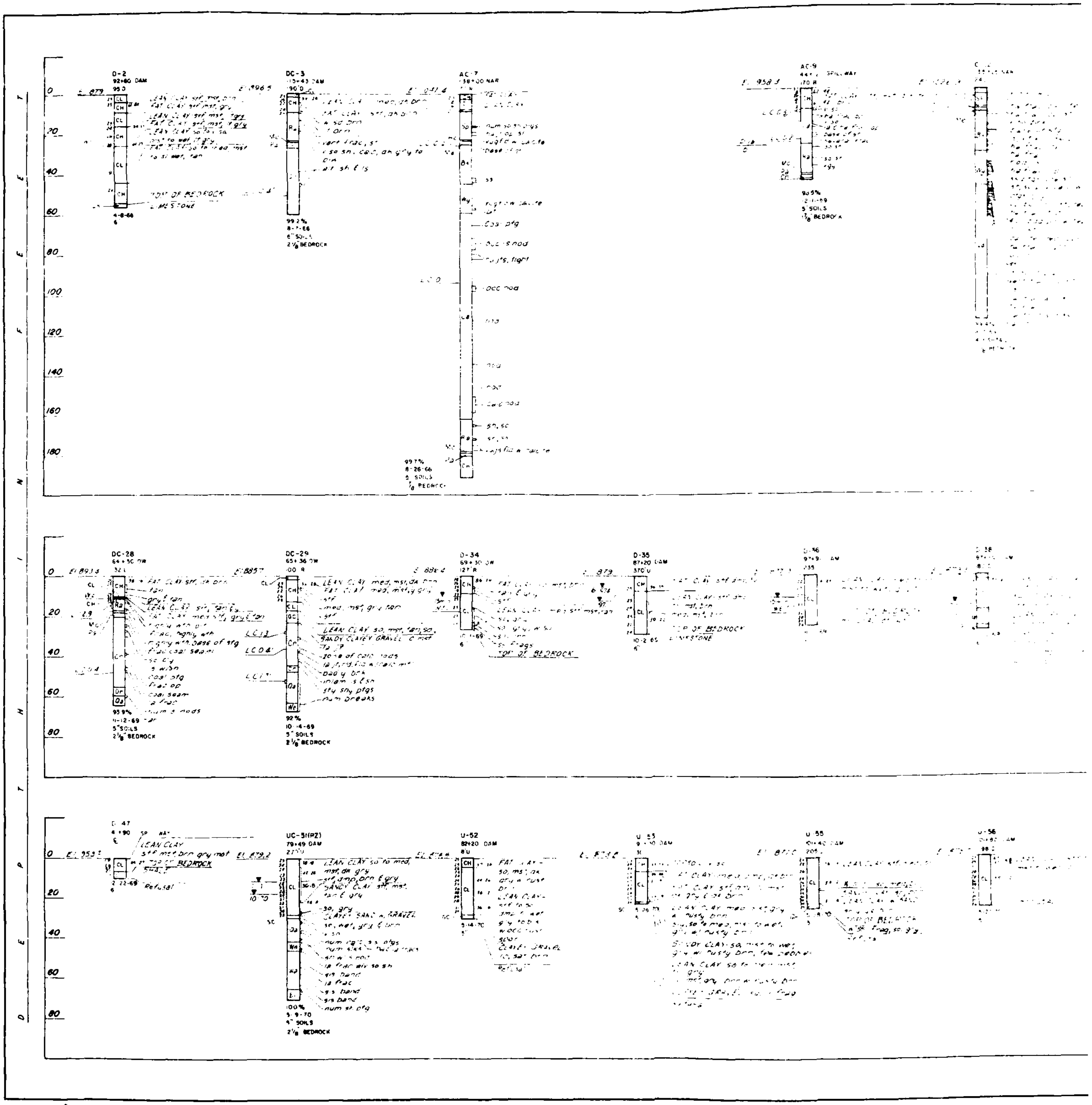
U S ARMY APRIL 1978

Submitted: CHIEF, GEOLOGY SECTION — Recommended: CHIEF, FOUNDATIONS & MAT'LS BR. — Approved: CHIEF, ENGINEERING DIVISION

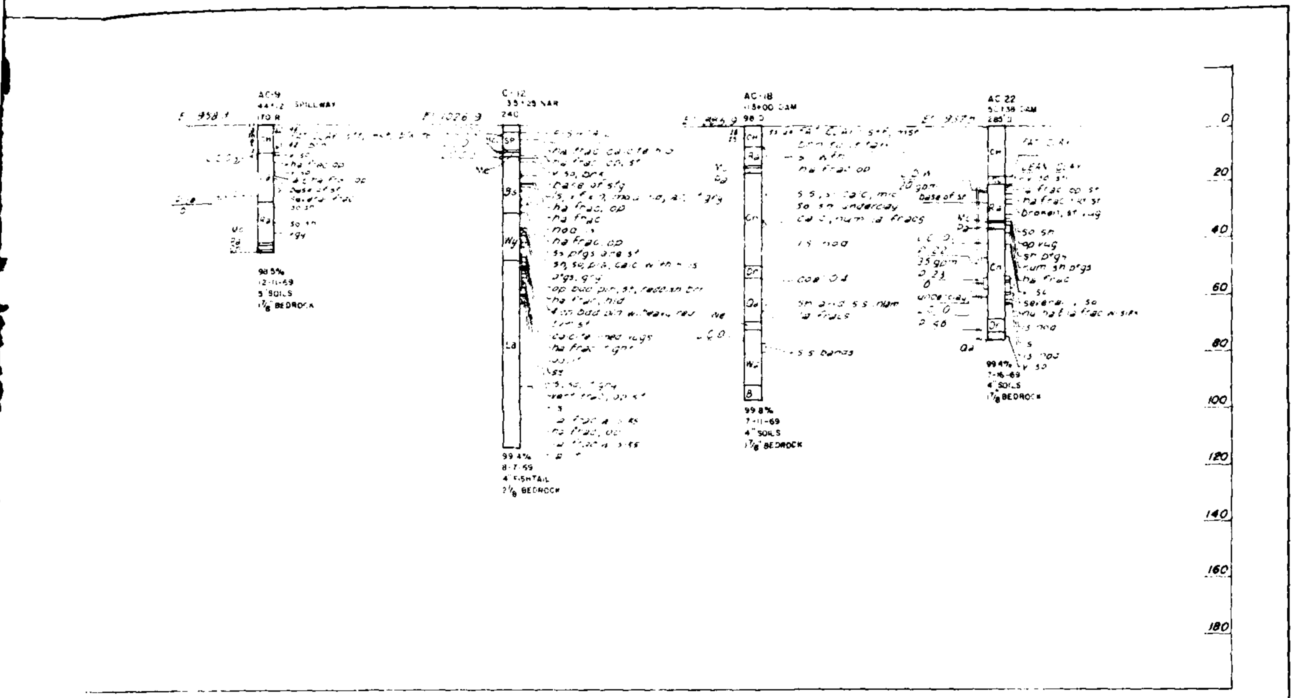
COMPILED BY M L S — DRAWN BY R L O — CHECKED BY J M M

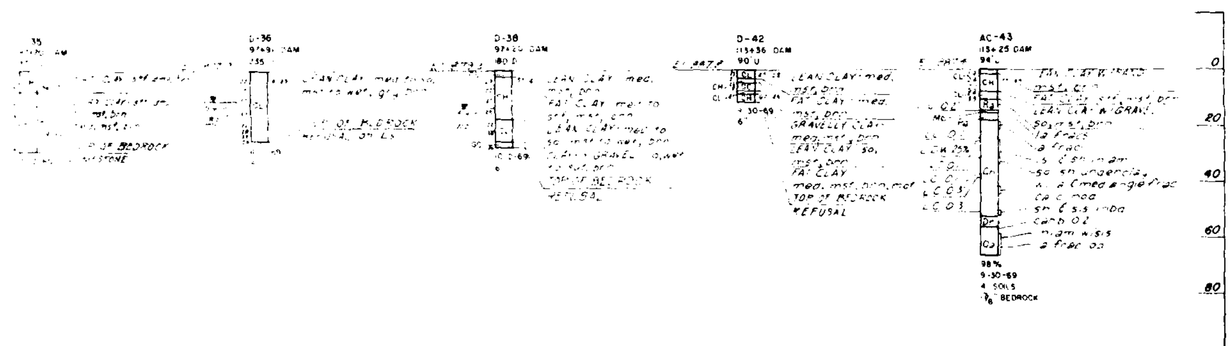
0-15-730

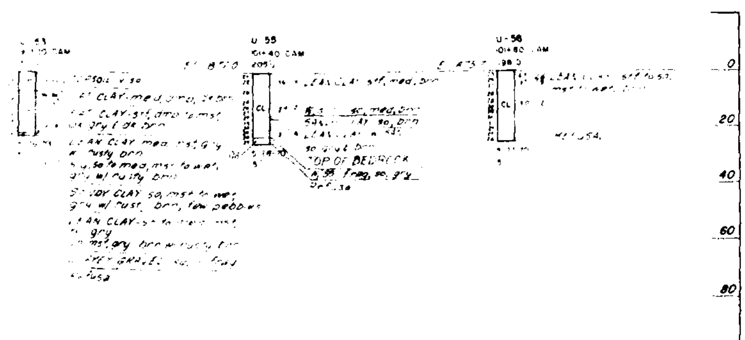
PLATE NO. 22



DEPTH IN FEET
D-2
DC-3
AC-7
AC-9
TOP OF BEDROCK
LIMESTONE
DC-28
DC-29
D-34
D-35
D-56
D-38
D-47
UC-51(PZ)
U-52
U-53
U-55
U-56
LEAN CLAY
FAT CLAY
SANDY CLAY
5" SOILS
2 1/8" BEDROCK
Refusal







NOTES:
For General Geologic Column and Legend, see Dwg No. E
For Plan of Borings, see Dwg No. E2

OW • OUTLET WORKS
NAR • NORTH ACCESS ROAD

RECORD DRAWING

JULY 1982

CONTRACT NO. DACW41 78 C 0113

SYM	DESCRIPTION	DATE	APP'D
	Revised for "As Built" conditions	6/28/83	

REVISIONS

BIG BULL CREEK, KANSAS

HILLSDALE LAKE

STAGE III CONSTRUCTION

LOGS OF EXPLORATIONS
DETACHED BORINGS

Dwg No E8
CORPS OF ENGINEERS
KANSAS CITY DISTRICT

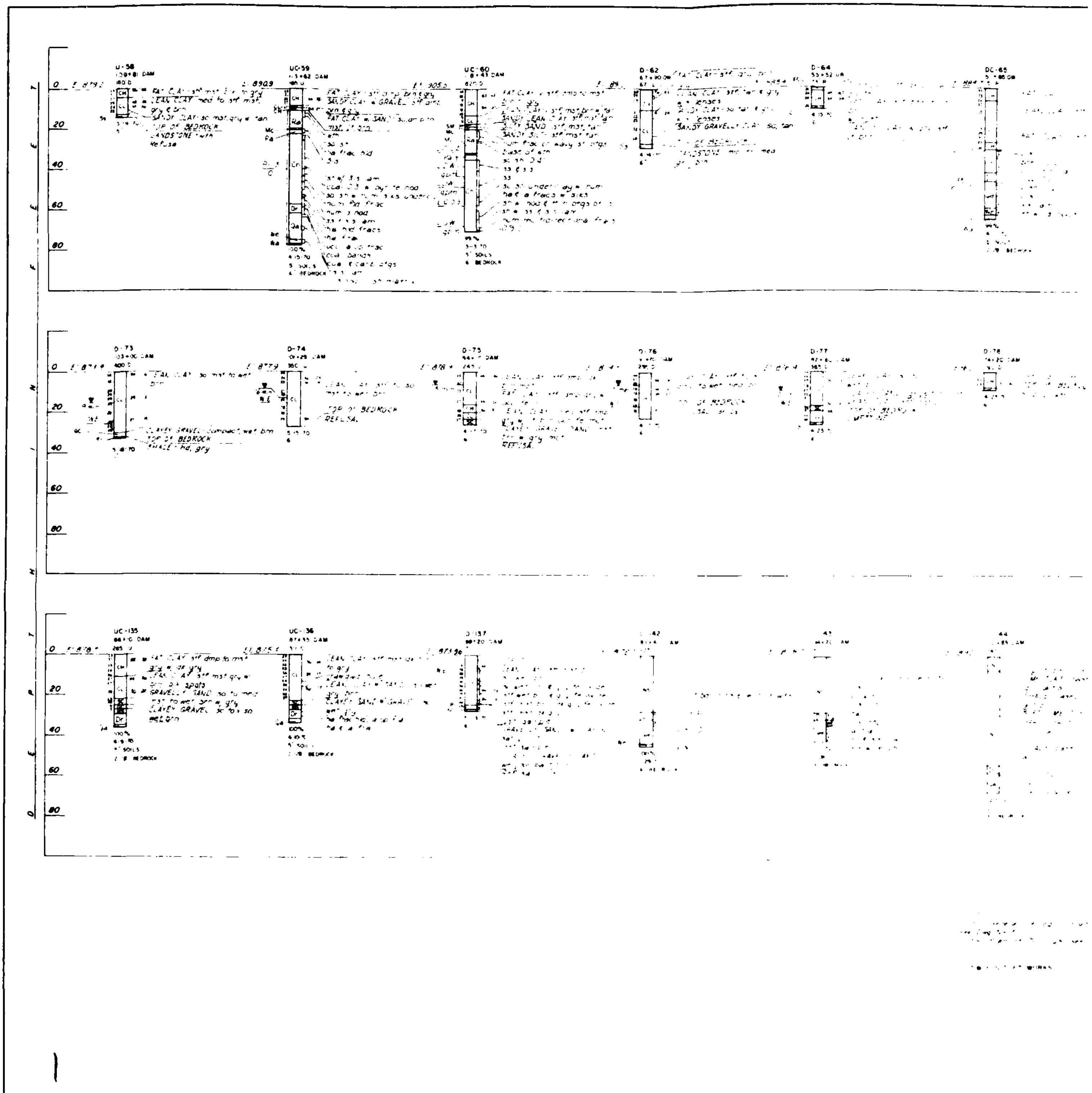
Scale as shown
U. S. ARMY
APRIL 1978

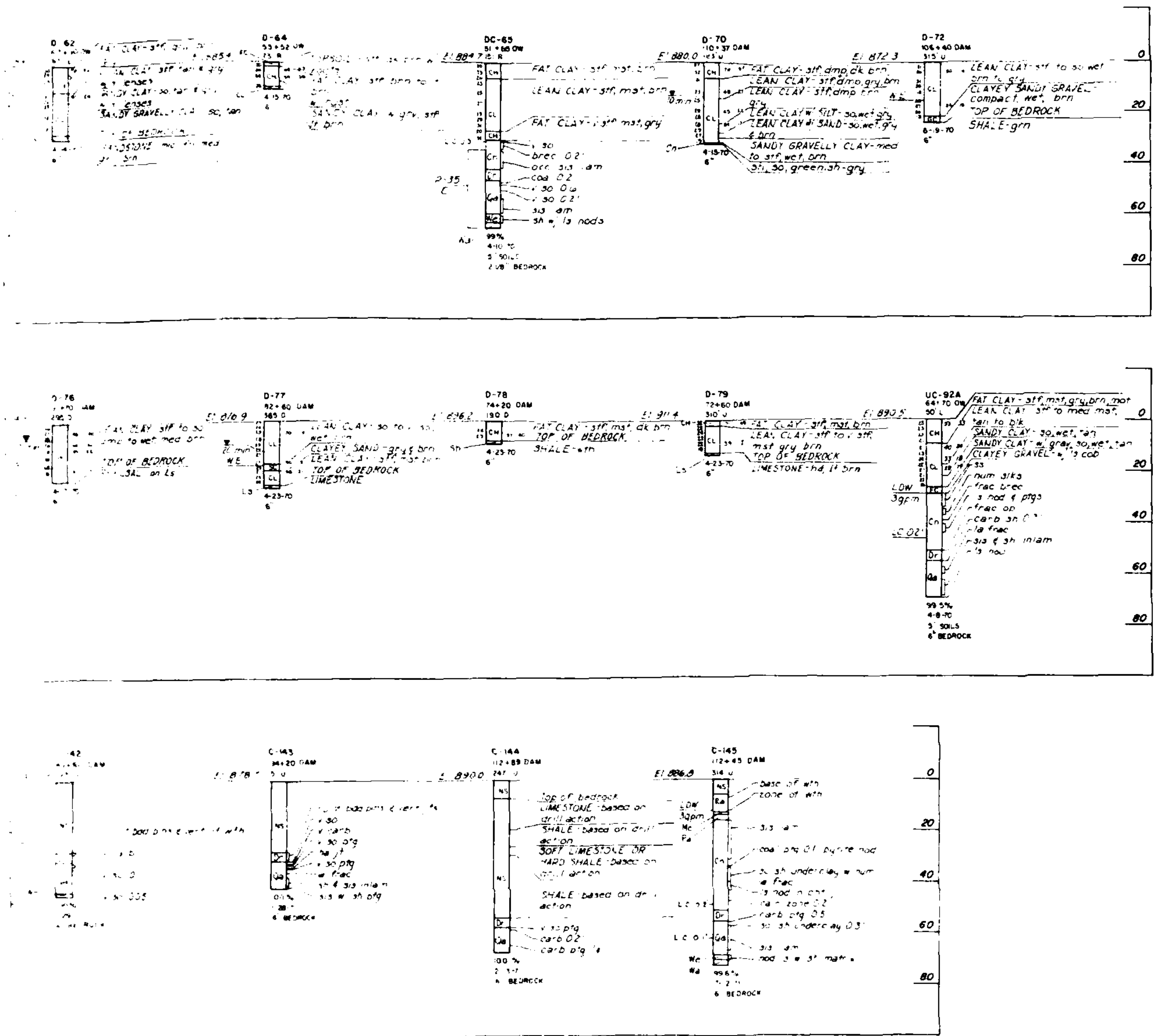
Submitted: CHIEF, GEOLOGY SECTION
Recommended: CHIEF, FOUNDATIONS & MATLS BR
Approved: CHIEF, ENGINEERING DIVISION

COMPILED BY J M M — DRAWN BY R L O — CHECKED BY J M M

FILE NO. 0-15-735

PLATE NO. 23


UC-59
UC-60
D-62
D-64
DC-65
D-73
D-74
D-75
D-76
D-77
D-78
UC-135
UC-136
D-137
0
20
40
60
80
FAT CLAY
LEAN CLAY
SANDY CLAY
SANDY GRAVELLY CLAY
CLAYEY GRAVEL
TOP OF BEDROCK
REFUSAL
5' SOILS
6' BEDROCK



RECORD DRAWING

JULY 1982

CONTRACT NO DACW41 78 C 0113

NOTES
For General Geologic Column and Legend see Dwg No E1
For Plan of Borings, see Dwg No E2

OW = OUTLET WORKS

SYM	DESCRIPTION	DATE	APP'D
	Revised for "As Built" conditions		

REVISIONS

BIG BULL CREEK, KANSAS

HILLSDALE LAKE

STAGE III CONSTRUCTION

LOGS OF EXPLORATIONS
DETACHED BORINGS

Dwg No E9

CORPS OF ENGINEERS
KANSAS CITY DISTRICT

Scale: as shown

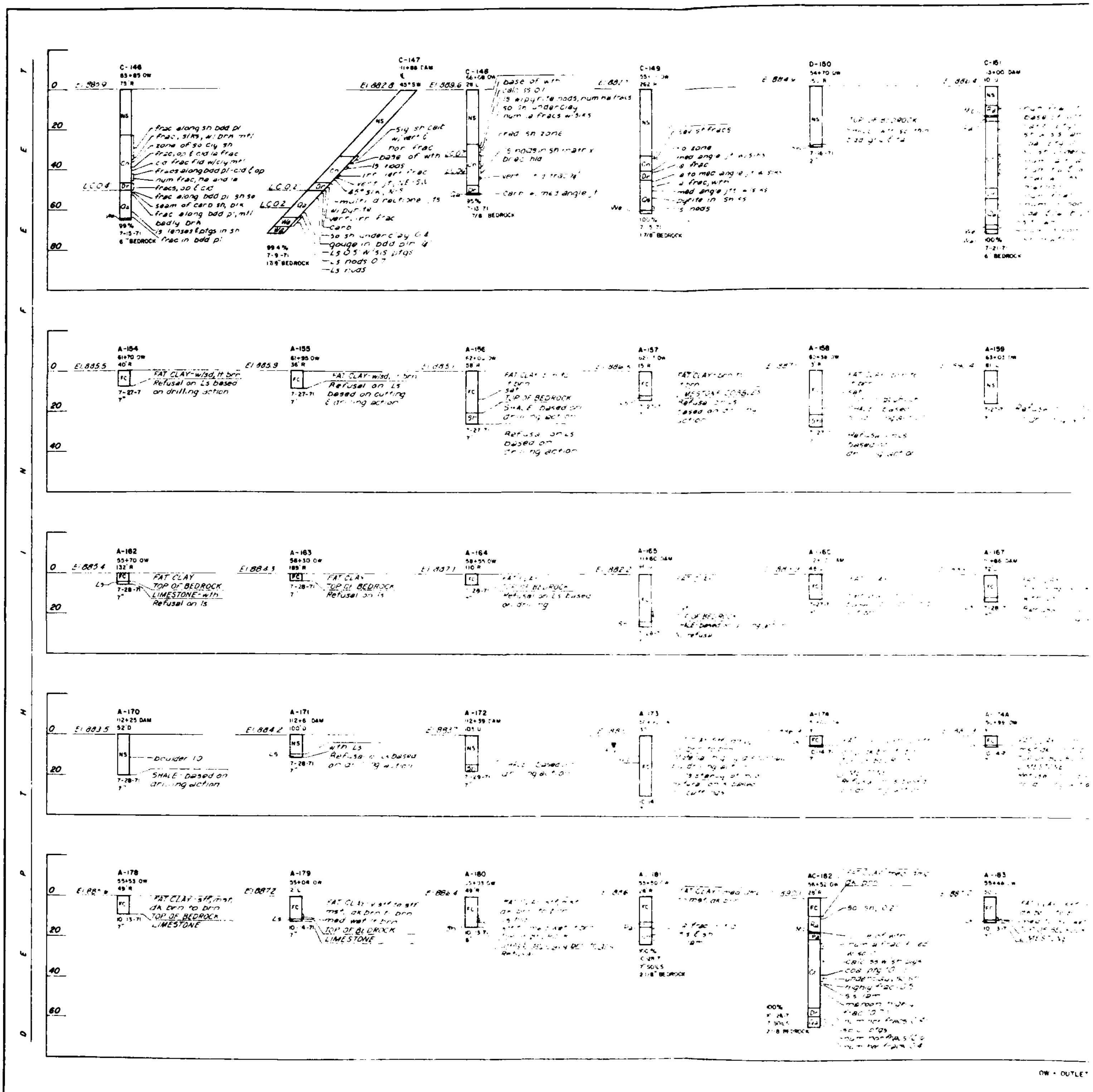
U S ARMY
APRIL 1978

Submitted: CHIEF, GEOLOGY SECTION
Recommended: CHIEF, FOUNDATIONS & MATLS BR
CHIEF, ENGINEERING DIVISION

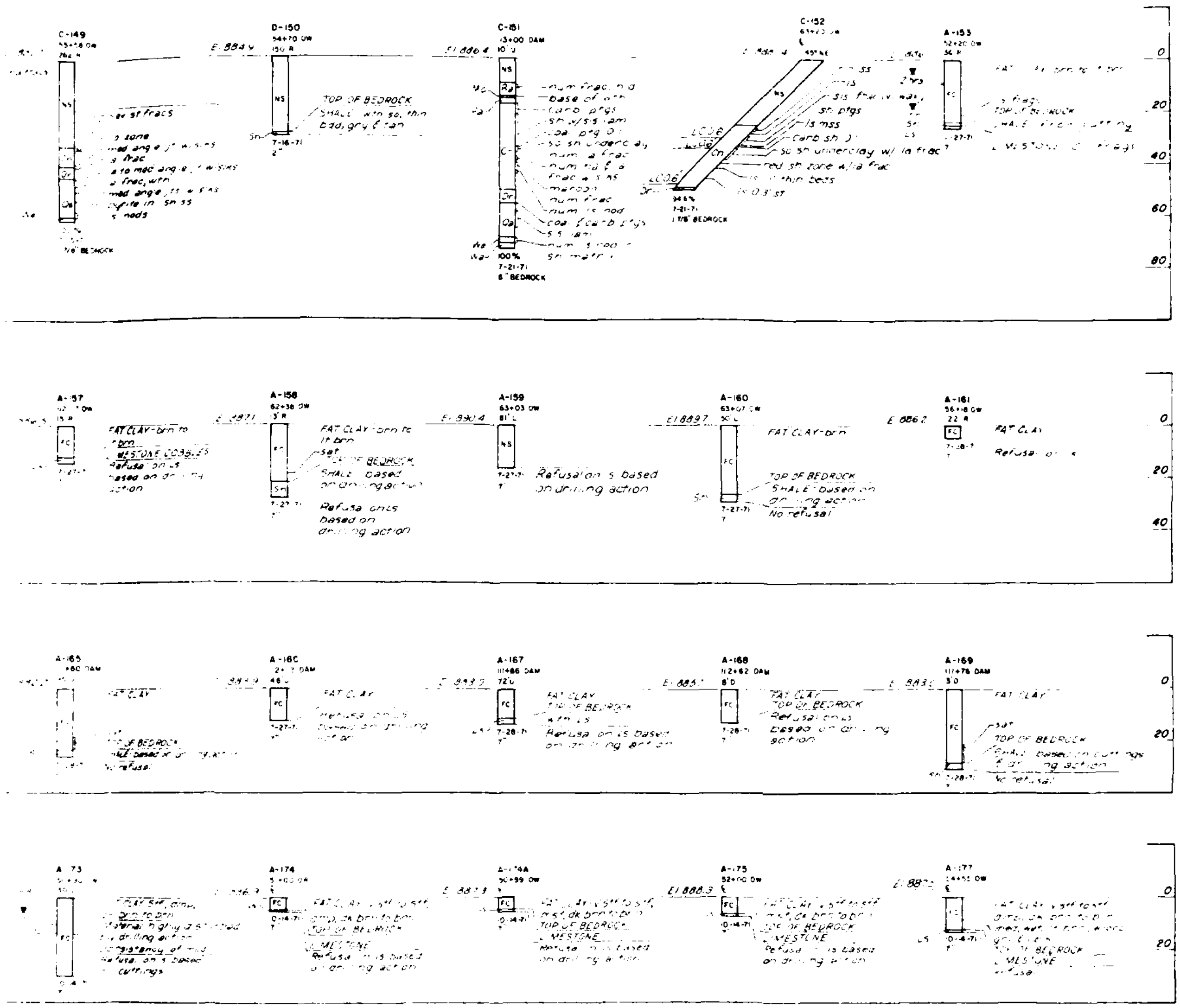
COMPILED BY J M M
DRAWN BY J P M
CHECKED BY J M M

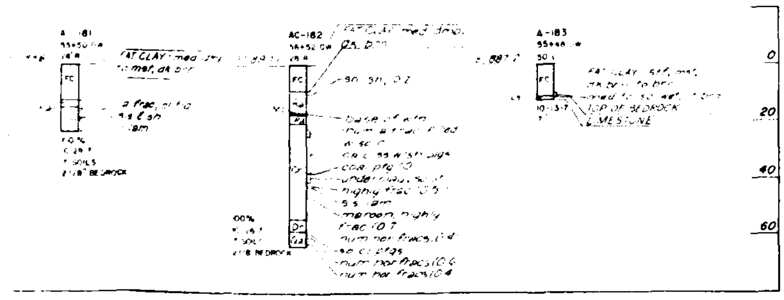
FILE NO 0-15-734

PLATE NO. 24



C-146
C-147
C-148
C-149
D-150
C-151
A-154
A-155
A-156
A-157
A-158
A-159
A-162
A-163
A-164
A-165
A-167
A-170
A-171
A-172
A-178
A-179
A-180
AC-182
OW = OUTLET





OW = OUTLET WORKS

NOTES
For general geologic column and legend see Dwg No.
For plan of borings see Dwg No.

RECORD DRAWING

JULY 1982

CONTRACT NO. DACW41-78-C-0113

Revised for "As Built" conditions — 6-28-83

SYM — DESCRIPTION — DATE — APP'D

REVISIONS

BIG BULL CREEK, KANSAS

HILLSDALE LAKE

STAGE III CONSTRUCTION

LOGS OF EXPLORATIONS DETACHED BORINGS

Dwg No. E10

CORPS OF ENGINEERS
KANSAS CITY DISTRICT

Scale as shown

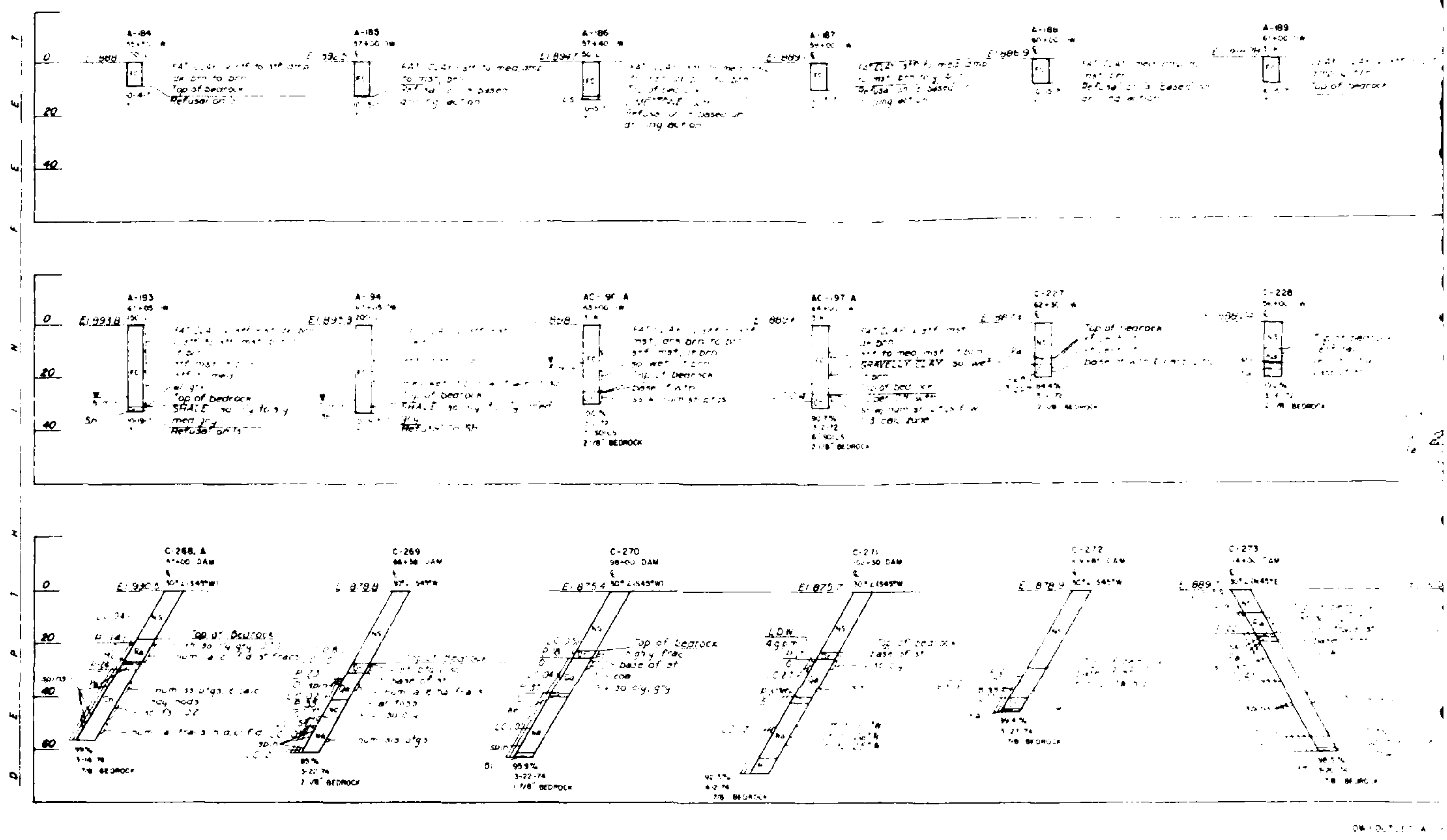
U. S. ARMY
APRIL 1978

Submitted — Recommended — Approved

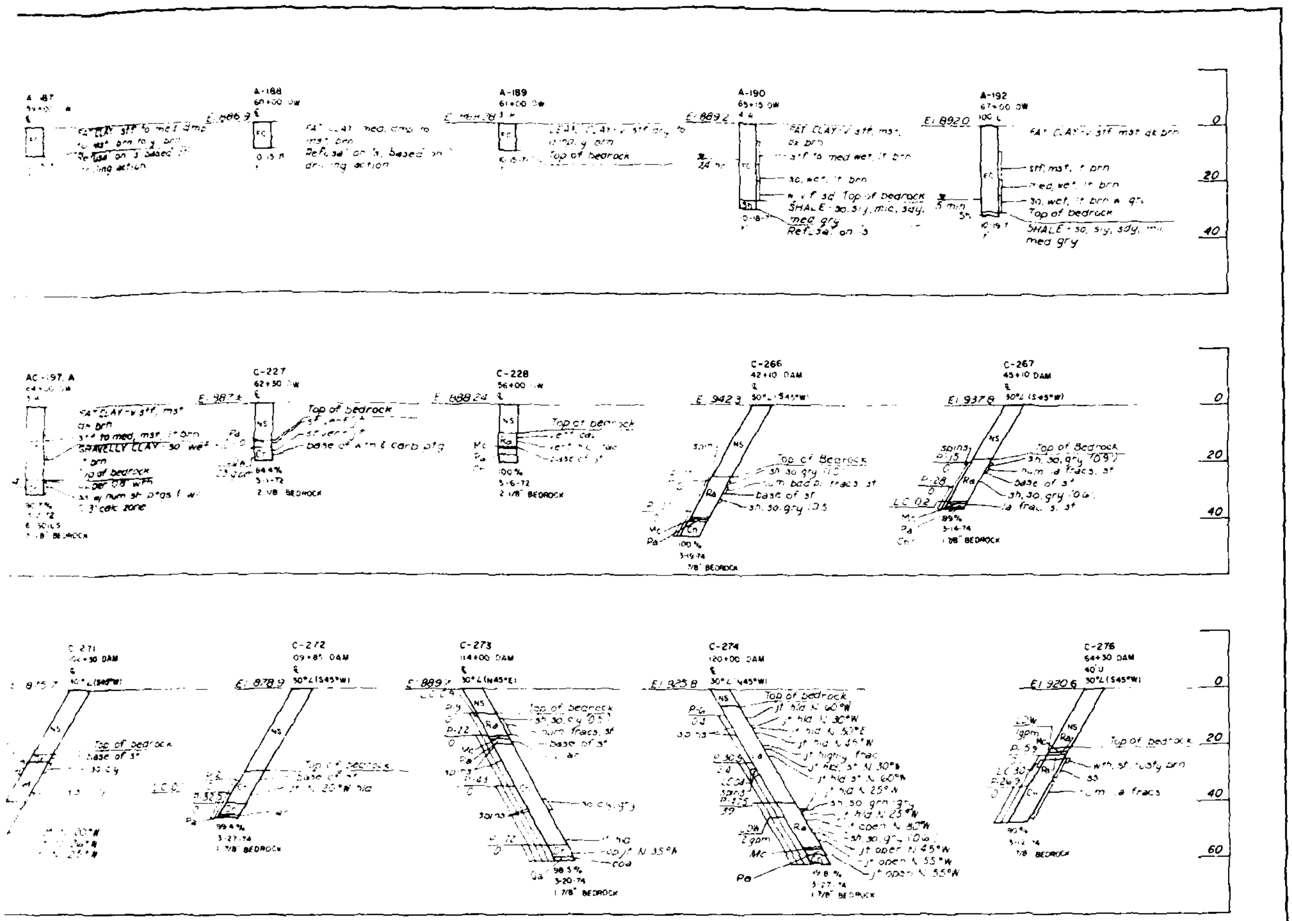
COMPILED BY J M M — DRAWN BY R L D — CHECKED BY J M M

0-15-735

PLATE NO 25



A-184
A-185
A-186
A-187
A-188
A-189
A-193
C-227
C-228
C-268.A
C-269
C-270
C-271
C-272
C-273
Top of bedrock
Refusal
BEDROCK



OW = OUTLET WORKS

Notes
For General Geologic Column and Legend, see Dwg No. E1
For Plan of Borings, see Dwg No. E2

RECORD DRAWING
JULY 1982
CONTRACT NO. DACW41 78 C 0113

SYM	DESCRIPTION	DATE	APPD
	Revised for "As Built" conditions		

REVISIONS

BIG BULL CREEK, KANSAS
HILLSDALE LAKE
STAGE III CONSTRUCTION

2

LOGS OF EXPLORATIONS
DETACHED BORINGS

Dwg No. E11
CORPS OF ENGINEERS
KANSAS CITY DISTRICT

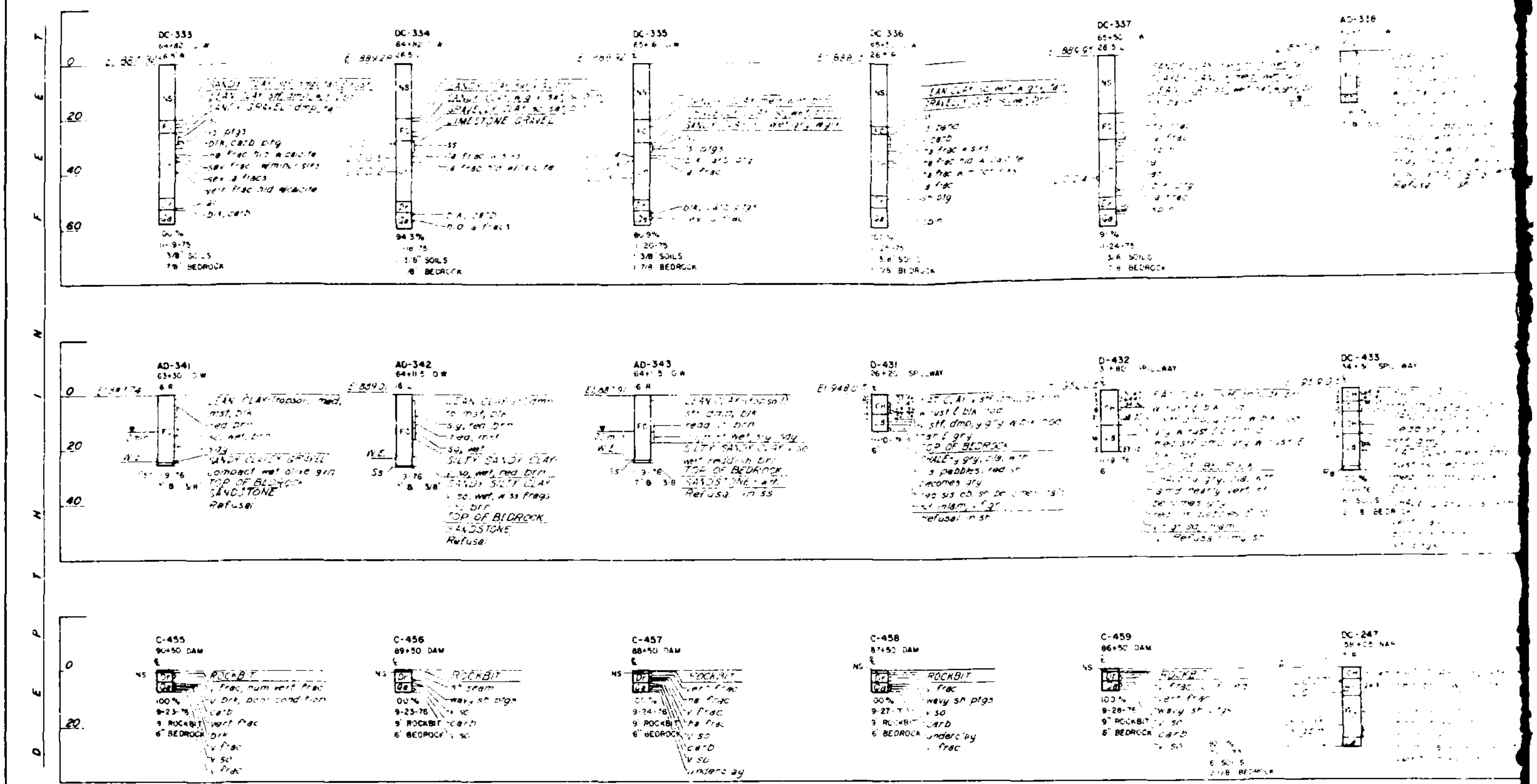
Scale as shown
U. S. ARMY
APRIL 1978

Submitted / Recommended / Approved

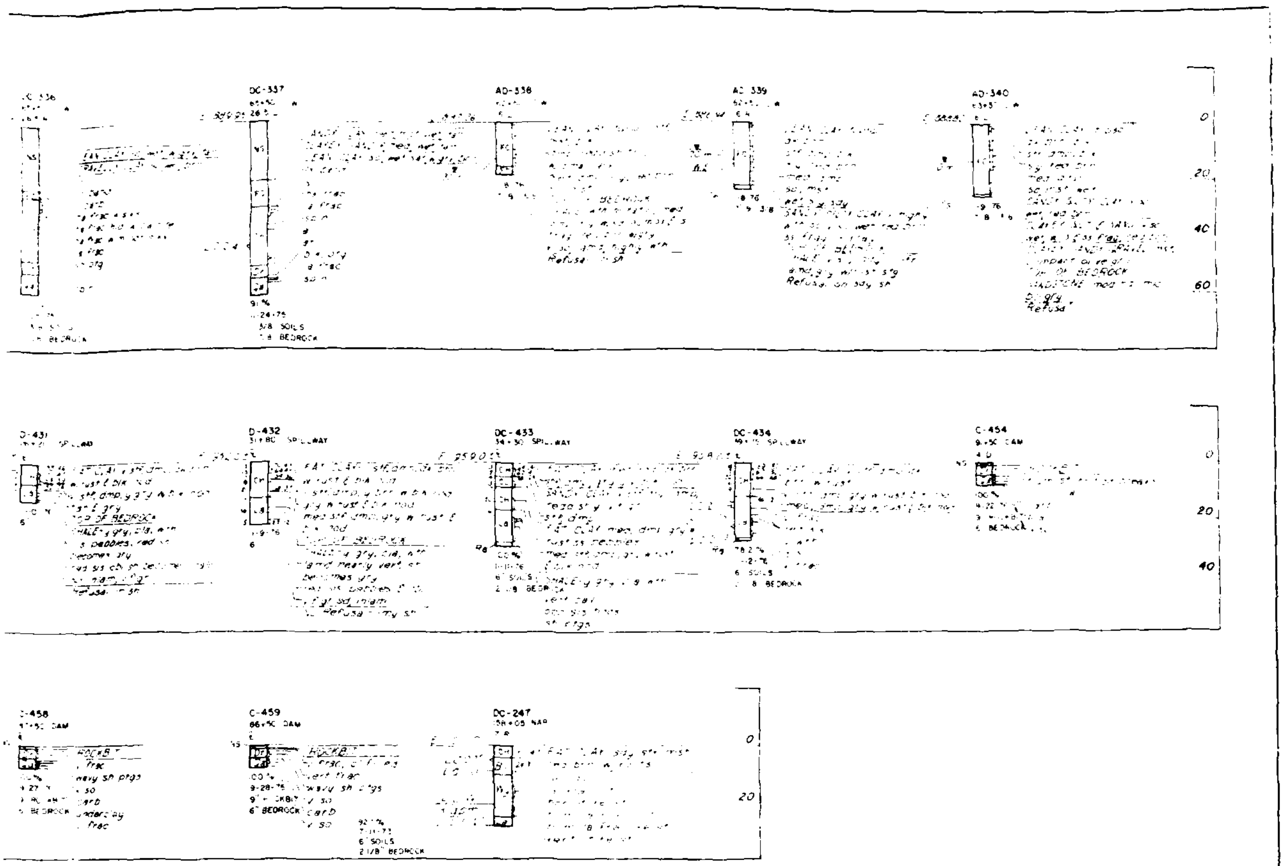
COMPILED BY J.M.M. DRAWN BY J.P.M. CHECKED BY J.M.M.

0-15-736

PLATE NO 26



OW = OUTLET WORKS
NAR = NORTH ACCESS ROAD



OW = OUTLET WORKS
NAR = NORTH ACCESS ROAD

RECORD DRAWING

SYM | DESCRIPTION | DATE | APPD

REVISIONS

BIG BULL CREEK KANSAS

HILLSDALE LAKE

STAGE III CONSTRUCTION

LOGS OF EXPLORATIONS
DETACHED BORINGS

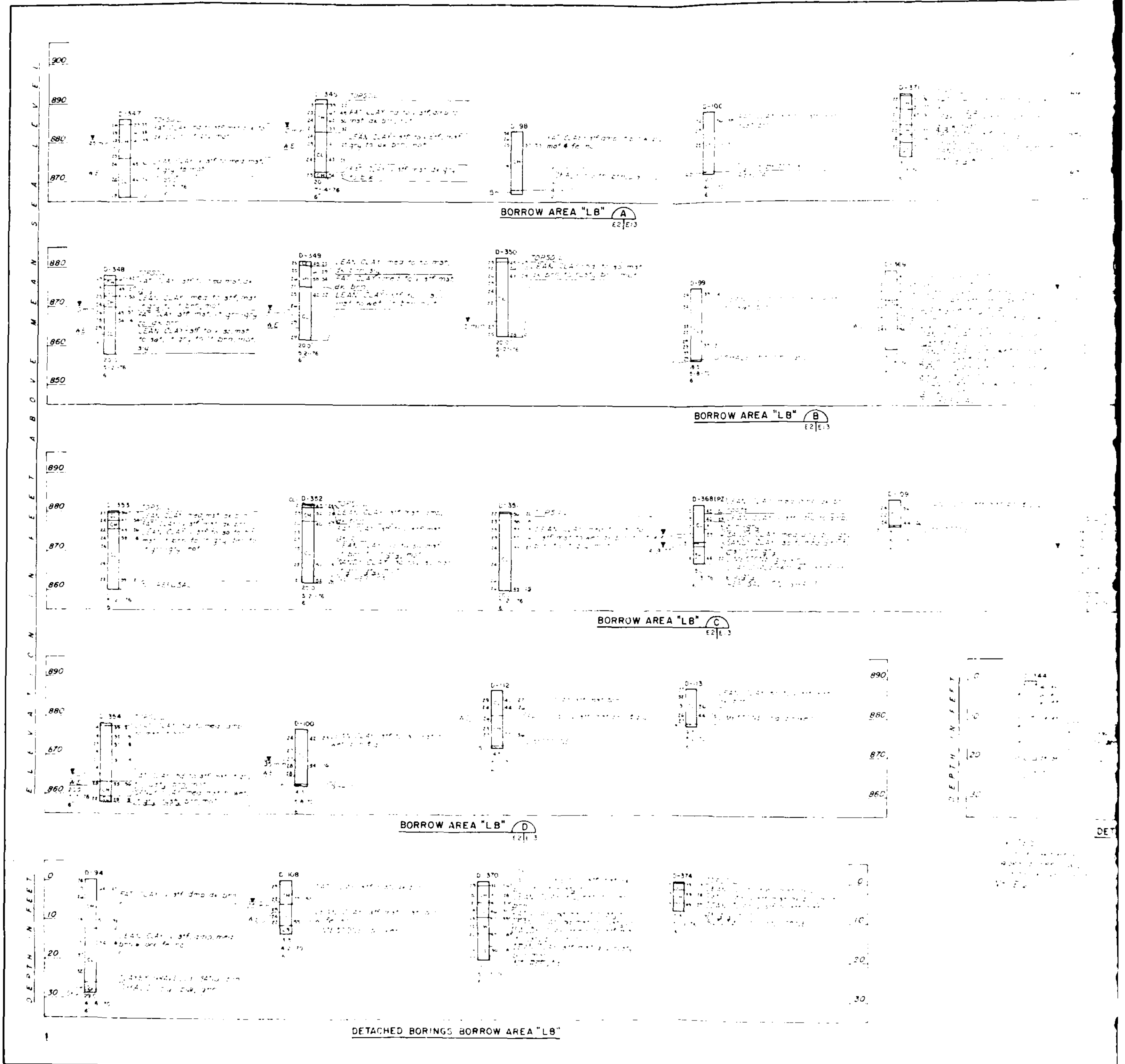
Dwg No E12
CORPS OF ENGINEERS
KANSAS CITY DISTRICT

Scale as shown
U. S. ARMY
APRIL 1978

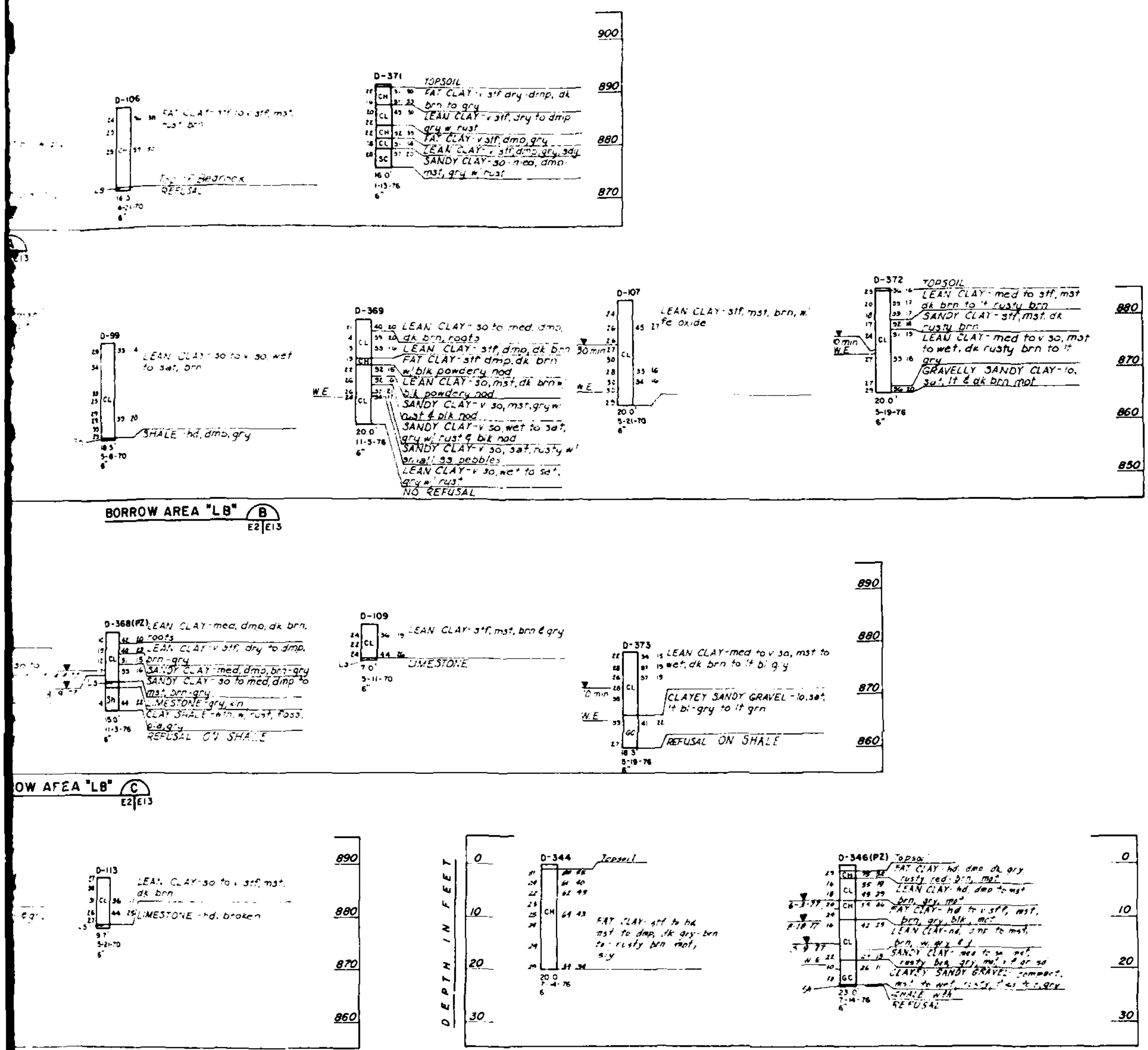
J M M | R L D | J M M

0-15-737

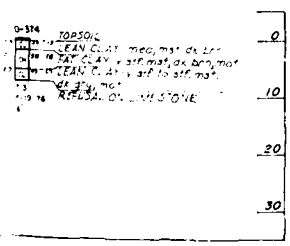
PLATE NO 27



ELEVATION IN FEET ABOVE MEAN SEA LEVEL
900
890
880
870
D-347
D-345
D-98
D-100
D-371
BORROW AREA "LB" A
E2|E13
880
870
860
850
D-348
D-349
D-350
D-99
BORROW AREA "LB" B
E2|E13
890
880
870
860
D-353
D-352
D-351
D-368(PZ)
BORROW AREA "LB" C
E2|E13
890
880
870
860
D-354
D-100
D-112
D-113
BORROW AREA "LB" D
E2|E13
DEPTH IN FEET
0
10
20
30
D-94
D-108
D-370
D-374
DETACHED BORINGS BORROW AREA "LB"
DET



DETACHED BORINGS BORROW AREA "LB"



NOTES
For General Geologic Column and legend, See Dwg. No E1
For Plan of borings, See Dwg No E2

RECORD DRAWING

JULY 1982
CONTRACT NO. DACW41 78 C 0113

SYM	DESCRIPTION	DATE	APP'D
	Revised for "As Built" conditions	6/28/83	

REVISIONS

BIG BULL CREEK, KANSAS

HILLSDALE LAKE

STAGE III CONSTRUCTION

2

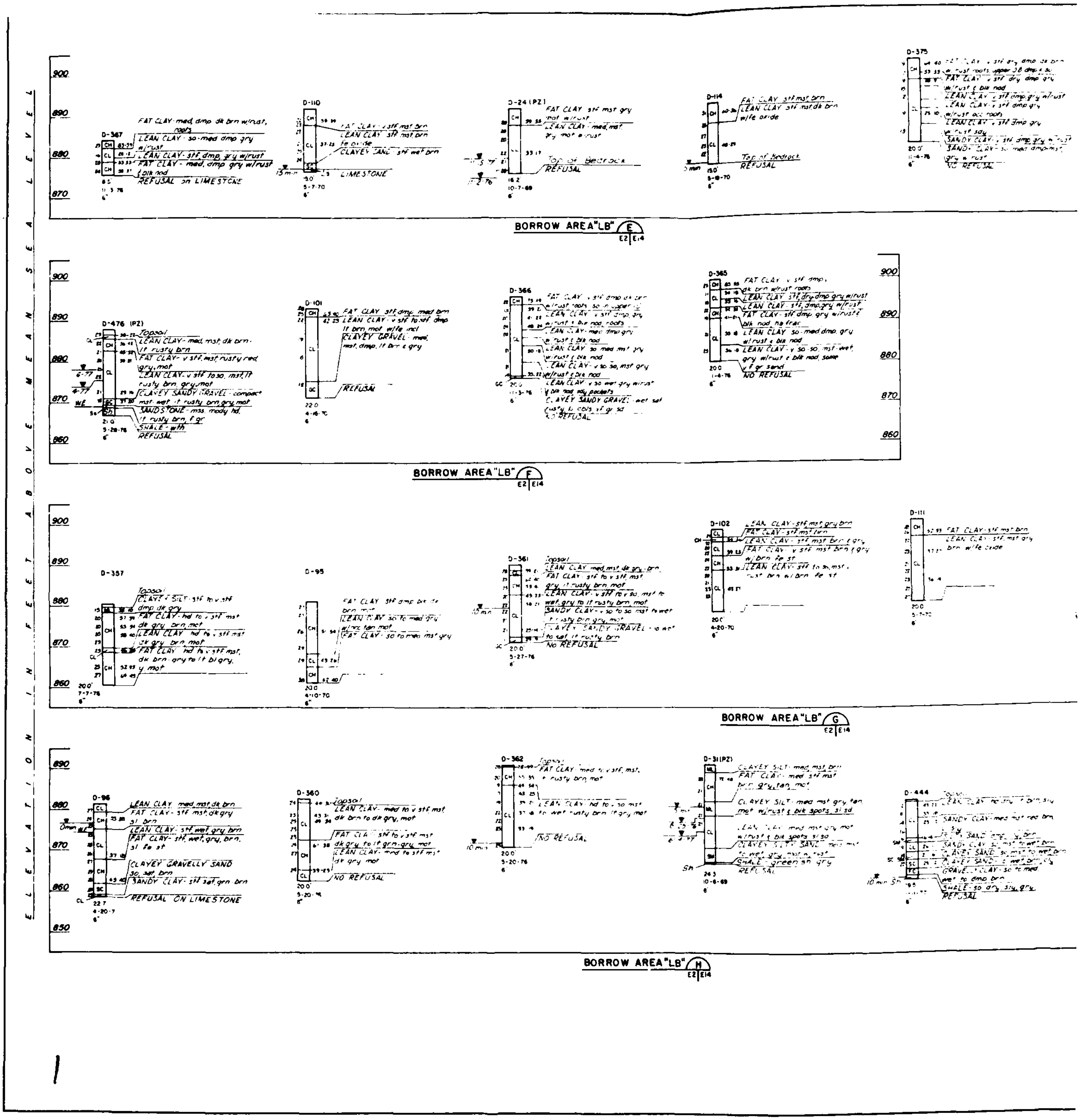
BORROW AREA
LOGS OF EXPLORATIONS

Dwg No E13
CORPS OF ENGINEERS
KANSAS CITY DISTRICT

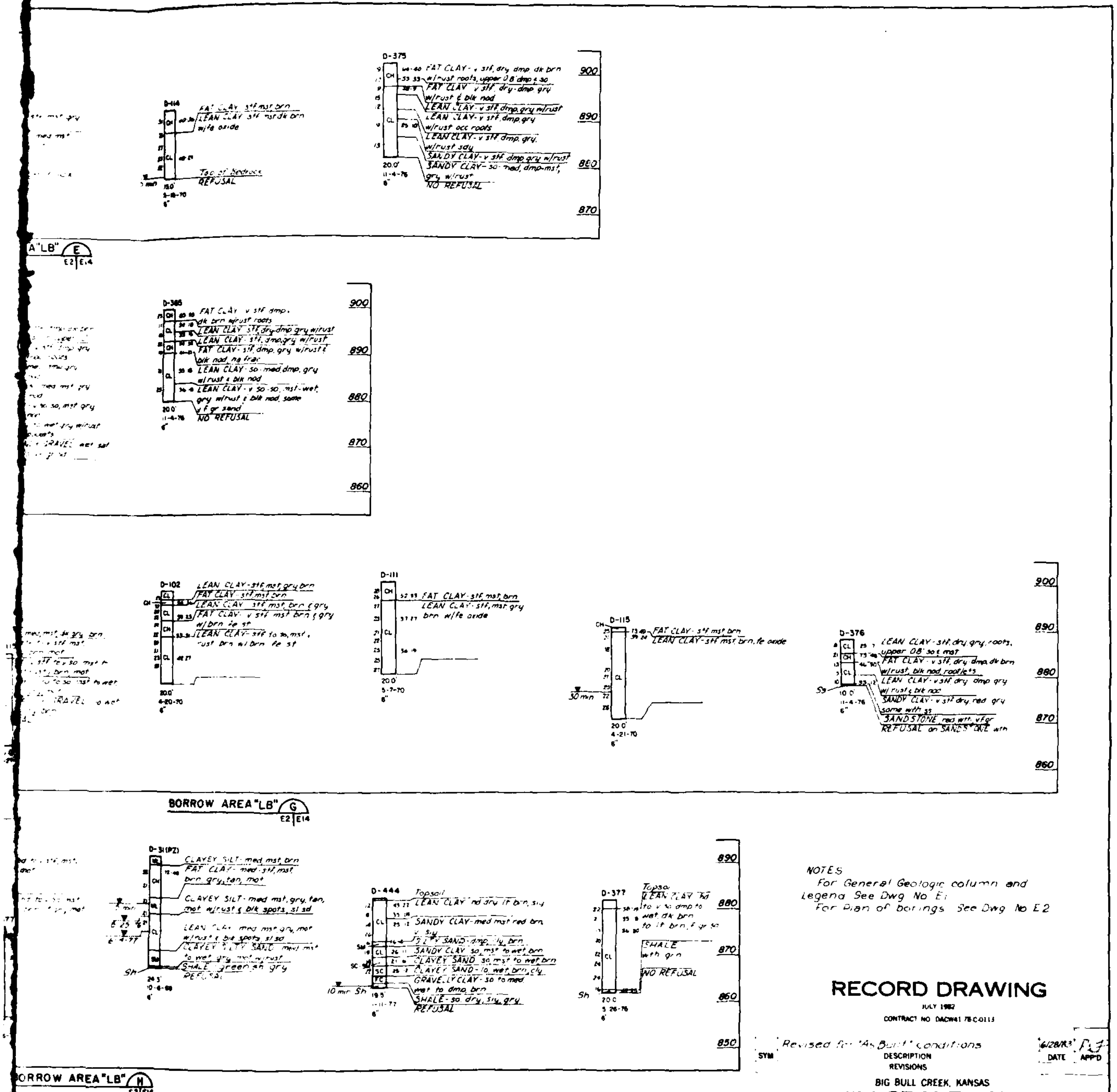
Scale: as shown
U. S. ARMY
APRIL 1978

Submitted / Recommended / Approved
COMPILED BY M T M — DRAWN BY J P M — CHECKED BY R G F
CHIEF, ENGINEERING DIVISION
FILE NO
0-15-738

PLATE NO 28



ELEVATION IN FEET ABOVE MEAN SEA LEVEL
D-367
D-110
D-24 (PZ)
D-114
D-375
BORROW AREA "LB" E
E2 E14
D-476 (PZ)
D-101
D-366
D-365
BORROW AREA "LB" F
E2 E14
D-357
D-95
D-361
D-102
D-111
BORROW AREA "LB" G
E2 E14
D-96
D-360
D-362
D-31 (PZ)
D-444
BORROW AREA "LB" H
E2 E14



NOTES
For General Geologic column and Legend See Dwg No E1
For Plan of borings See Dwg No E2

RECORD DRAWING

JULY 1982

CONTRACT NO DACW41 78-C-0113

SYM	DESCRIPTION	DATE	APP'D
	Revised for "As Built" conditions	6/28/83	

REVISIONS

BIG BULL CREEK, KANSAS

HILLSDALE LAKE

STAGE III CONSTRUCTION

BORROW AREAS LOGS OF EXPLORATIONS

2

Dwg No E14
CORPS OF ENGINEERS
KANSAS CITY DISTRICT

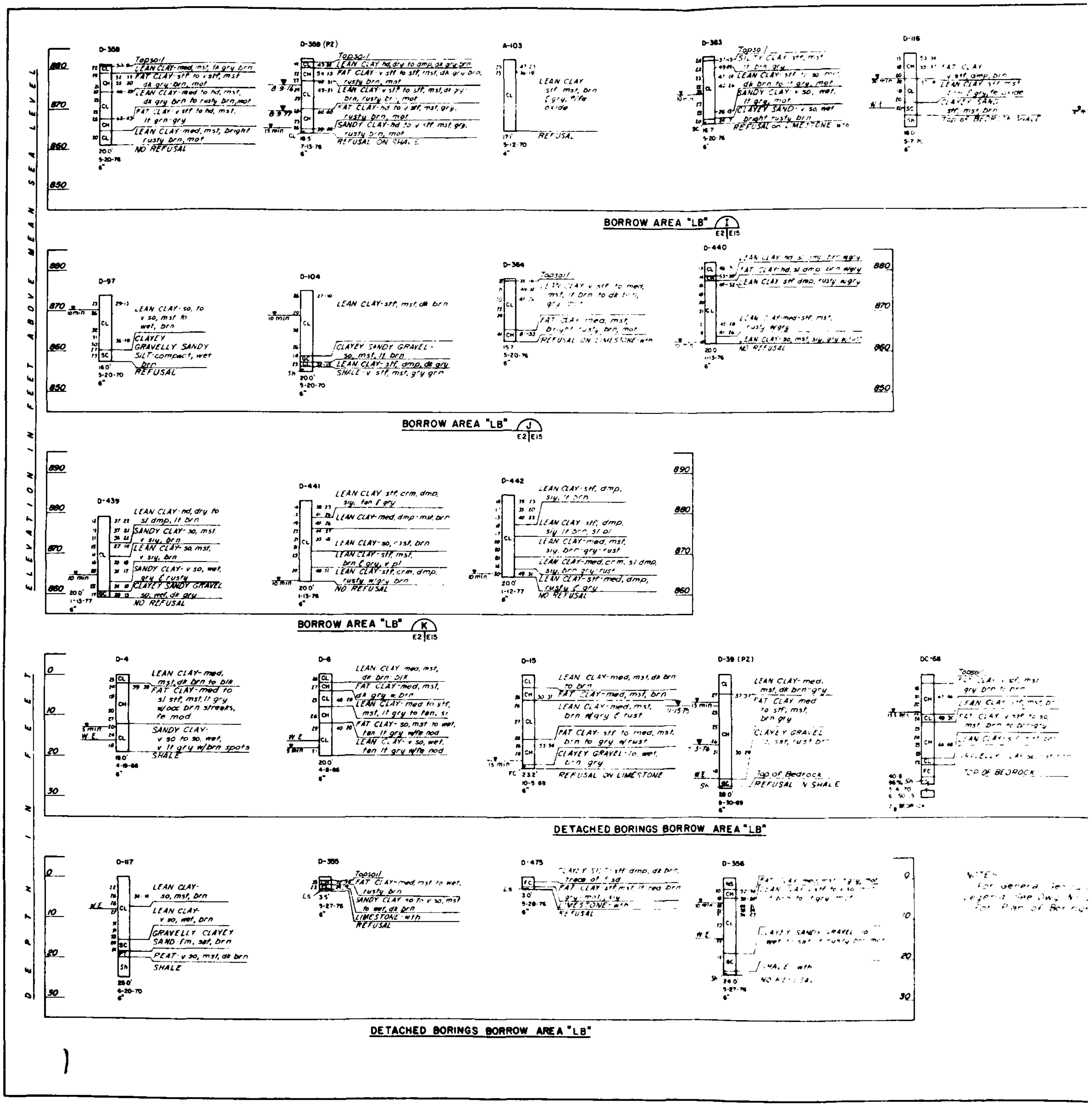
Submitted: CHIEF, DAMS & FOUNDATIONS SECT
Recommended: CHIEF, FOUNDATIONS & MATLS BR
Approved: CHIEF, ENGINEERING DIVISION

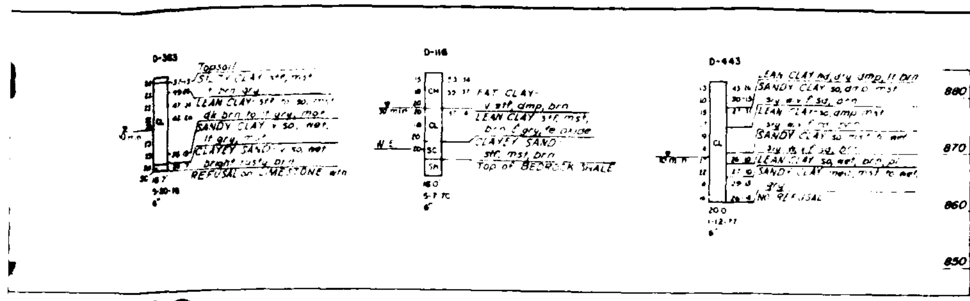
COMPILED BY: M T M
DRAWN BY: W L C
CHECKED BY: R G P

Scale: as shown
U S ARMY
APRIL 1978

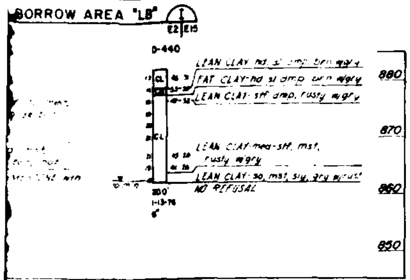
FILE NO
C-15-739

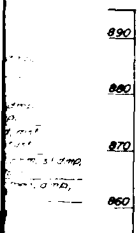
PLATE NO 29

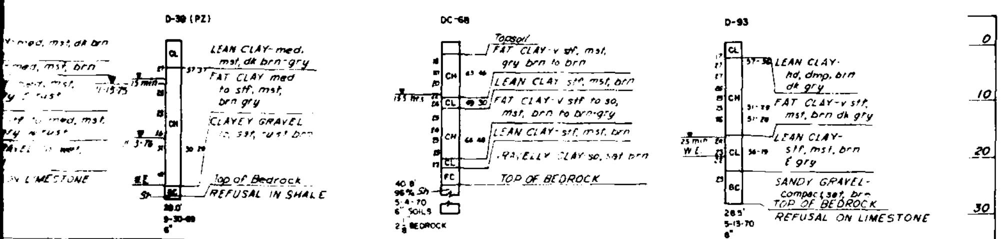
ELEVATION IN FEET ABOVE MEAN SEA LEVEL
D-358
Topsoil
LEAN CLAY-med, mst, lt gry brn
FAT CLAY-stf to v stf, mst
dk gry-brn, mot
LEAN CLAY-med to hd, mst, dk gry brn to rusty brn, mot
LEAN CLAY-med, mst, bright rusty brn, mot
NO REFUSAL
D-359 (PZ)
Topsoil
LEAN CLAY-hd, dry to dmp, dk gry brn
FAT CLAY-v stf to stf, mst, dk gry brn, rusty brn, mst
FAT CLAY-hd to v stf, mst, gry, rusty brn, mot
SANDY CLAY-hd to v stf mst, gry, rusty brn, mot
REFUSAL ON SHALE
A-103
LEAN CLAY stf, mst, brn & gry, w/fe oxide
REFUSAL
D-363
Topsoil
SANDY CLAY-v so, wet, lt gry, mot
CLAYEY SAND-v so, wet
REFUSAL ON LIMESTONE
D-116
FAT CLAY
CLAYEY SAND
BORROW AREA "LB" I
E2 E15
D-97
LEAN CLAY-so, to v so, mst to wet, brn
CLAYEY GRAVELLY SANDY SILT-compact, wet brn
REFUSAL
D-104
LEAN CLAY-stf, mst, dk brn
CLAYEY SANDY GRAVEL-so, mst, lt brn
LEAN CLAY-stf, dmp, dk gry
SHALE-v stf, mst, g'y grn
D-364
Topsoil
REFUSAL ON LIMESTONE
D-440
LEAN CLAY stf dmp, rusty w/gry
NO REFUSAL
BORROW AREA "LB" J
E2 E15
D-439
LEAN CLAY-hd, dry to sl dmp, lt brn
SANDY CLAY-so, mst, v sly, brn
LEAN CLAY-so, mst, v sly, brn
SANDY CLAY-v so, wet, gry & rusty
CLAYEY SANDY GRAVEL so, wet, dk gry
NO REFUSAL
D-441
LEAN CLAY stf, crm, dmp, sly, tan & gry
LEAN CLAY-med, dmp-mst, brn
LEAN CLAY-so, mst, brn
LEAN CLAY-stf, mst, brn & gry, v pl
LEAN CLAY-stf, crm, dmp, rusty w/gry brn
NO REFUSAL
D-442
LEAN CLAY-stf, dmp, sly, lt brn
LEAN CLAY stf, dmp, sly lt brn, sl pl
LEAN CLAY-med, mst, sly, brn-gry-rust
LEAN CLAY-med, crm, sl dmp, sly, brn gry-rust
LEAN CLAY-stf-med, dmp, rusty & gry
NO REFUSAL
BORROW AREA "LB" K
E2 E15
DEPTH IN FEET
D-4
LEAN CLAY-med, mst, dk brn to blk
FAT CLAY-med to sl stf, mst, lt gry w/occ brn streeks, fe mod
SANDY CLAY-v so to so, wet, v lt gry w/brn spots
SHALE
D-6
LEAN CLAY med, mst, dk brn-blk
FAT CLAY-med, mst, dk gry & brn
LEAN CLAY-med to stf, mst, lt gry to tan, sl
FAT CLAY-so, mst to wet, tan lt gry w/fe nod
LEAN CLAY-v so, wet, tan lt gry w/fe nod
D-15
LEAN CLAY-med, mst, dk brn to brn
FAT CLAY-med, mst, brn
LEAN CLAY-med, mst, brn w/gry & rust
FAT CLAY-stf to med, mst, brn to gry w/rust
CLAYEY GRAVEL-so, wet, brn gry
REFUSAL ON LIMESTONE
D-39 (PZ)
LEAN CLAY-med, mst, dk brn-gry
FAT CLAY med to stf, mst, brn gry
CLAYEY GRAVEL
Top of Bedrock
REFUSAL ON SHALE
DC-68
Topsoil
LEAN CLAY
FAT CLAY
TOP OF BEDROCK
DETACHED BORINGS BORROW AREA "LB"
D-117
LEAN CLAY-so, mst, brn
LEAN CLAY-v so, wet, brn
GRAVELLY CLAYEY SAND fm, sat, brn
PEAT-v so, mst, dk brn
SHALE
D-355
Topsoil
FAT CLAY-med, mst to wet, rusty brn
SANDY CLAY so to v so, mst to wet, dk brn
LIMESTONE with REFUSAL
D-475
CLAYEY SILT-stf dmp, dk brn, trace of sd
FAT CLAY
LIMESTONE with REFUSAL
D-356
FAT CLAY
LEAN CLAY
CLAYEY SANDY GRAVEL
SHALE with NO REFUSAL
DETACHED BORINGS BORROW AREA "LB"
NOTES
For General Legend See Dwg
For Plan of Borings



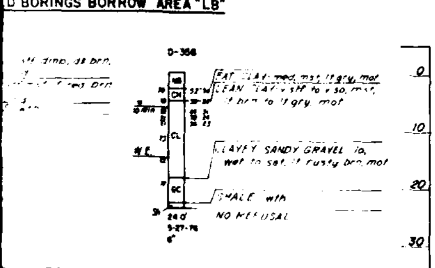
BORROW AREA "LB"







D BORINGS BORROW AREA "LB"



NOTES
For General Geologic Column and Legend See Dwg No E1
For Plan of Borings, See Dwg No E2

RECORD DRAWING

JULY 1982
CONTRACT NO DACW41 78 C 0113

SYM	DESCRIPTION	DATE	APP'D
	Revised for "As Built" conditions	6/2883	

REVISIONS

BIG BULL CREEK, KANSAS

HILLSDALE LAKE

STAGE III CONSTRUCTION

BORROW AREA
LOGS OF EXPLORATIONS

2

Dwg No E15
CORPS OF ENGINEERS
KANSAS CITY DISTRICT

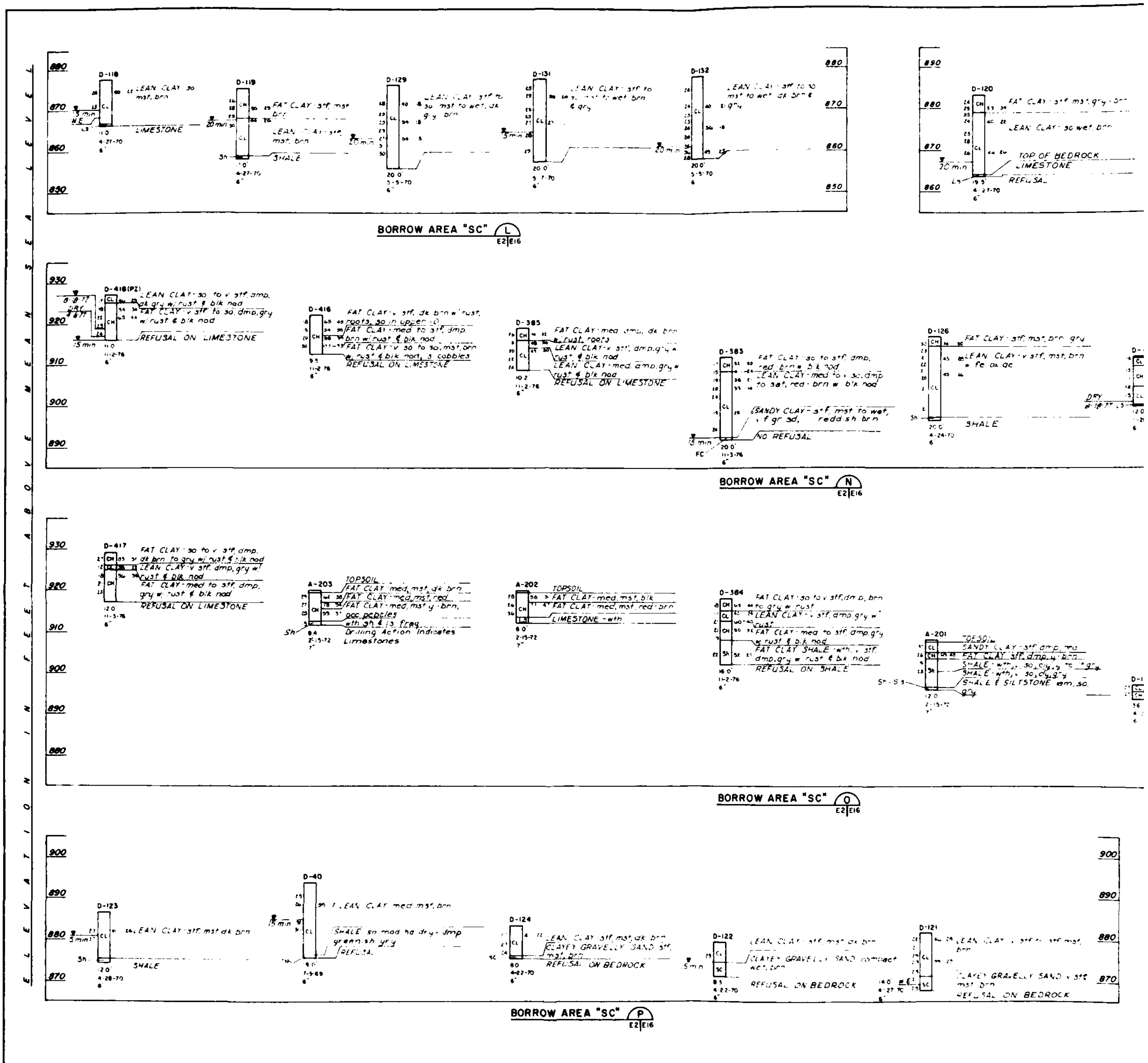
Scale: as shown
U S ARMY
APRIL 1978

Submitted: CHIEF, DAMS & FOUNDATIONS SECT
Recommended: CHIEF, FOUNDATIONS & MAT'LS BR
Approved: CHIEF, ENGINEERING DIVISION

COMPILED BY M T M — DRAWN BY J P M — CHECKED BY R G F

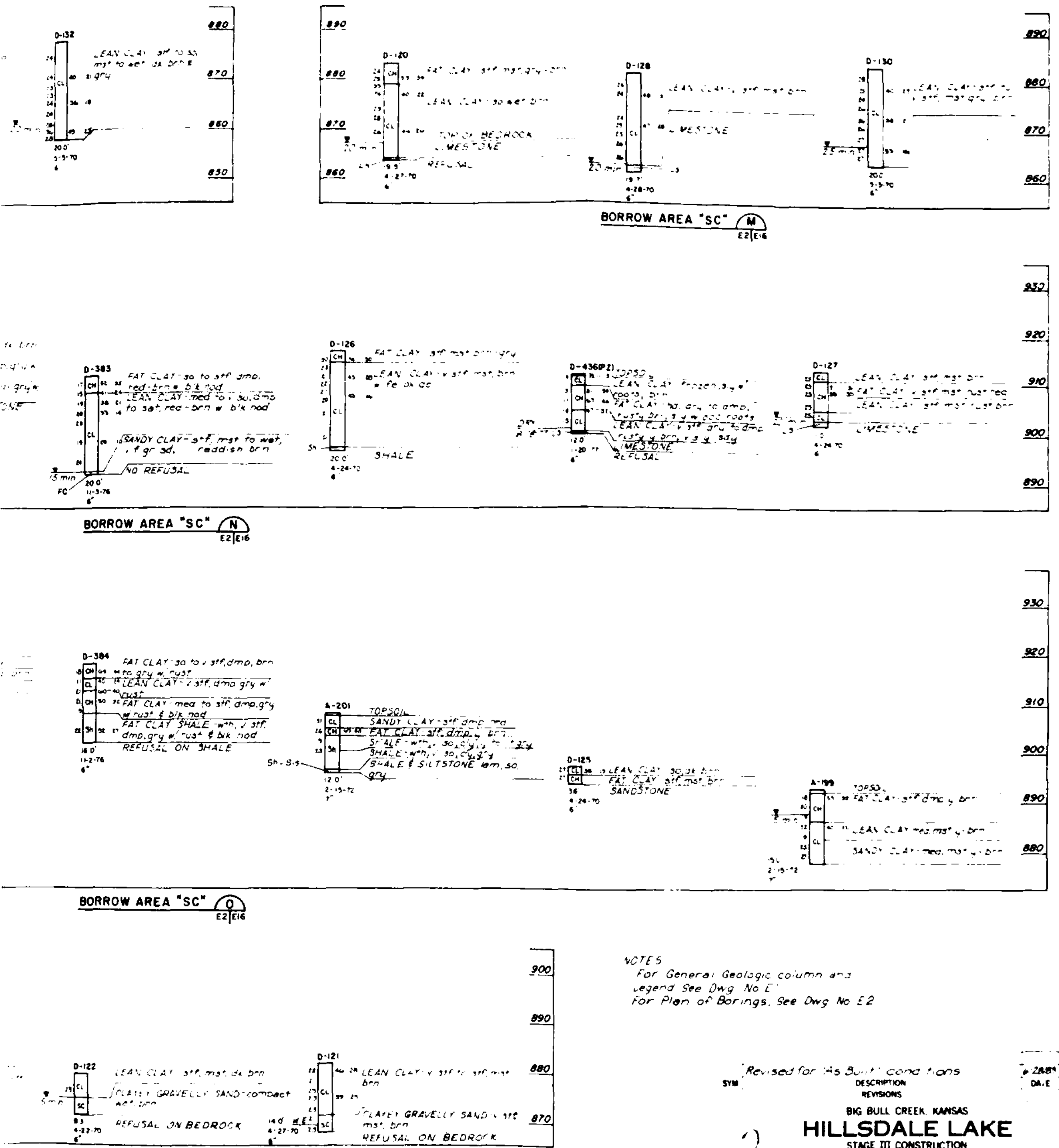
FILE NO 0-15-740

PLATE NO 30



RECORD DRAWING

JULY 1982



NOTES
For General Geologic column and Legend See Dwg No E1
For Plan of Borings, See Dwg No E2

Revised for "As Built" conditions

SYM | DESCRIPTION | DATE | APPD
REVISIONS

BIG BULL CREEK, KANSAS
HILLSDALE LAKE
STAGE III CONSTRUCTION

BORROW AREA
LOGS OF EXPLORATIONS

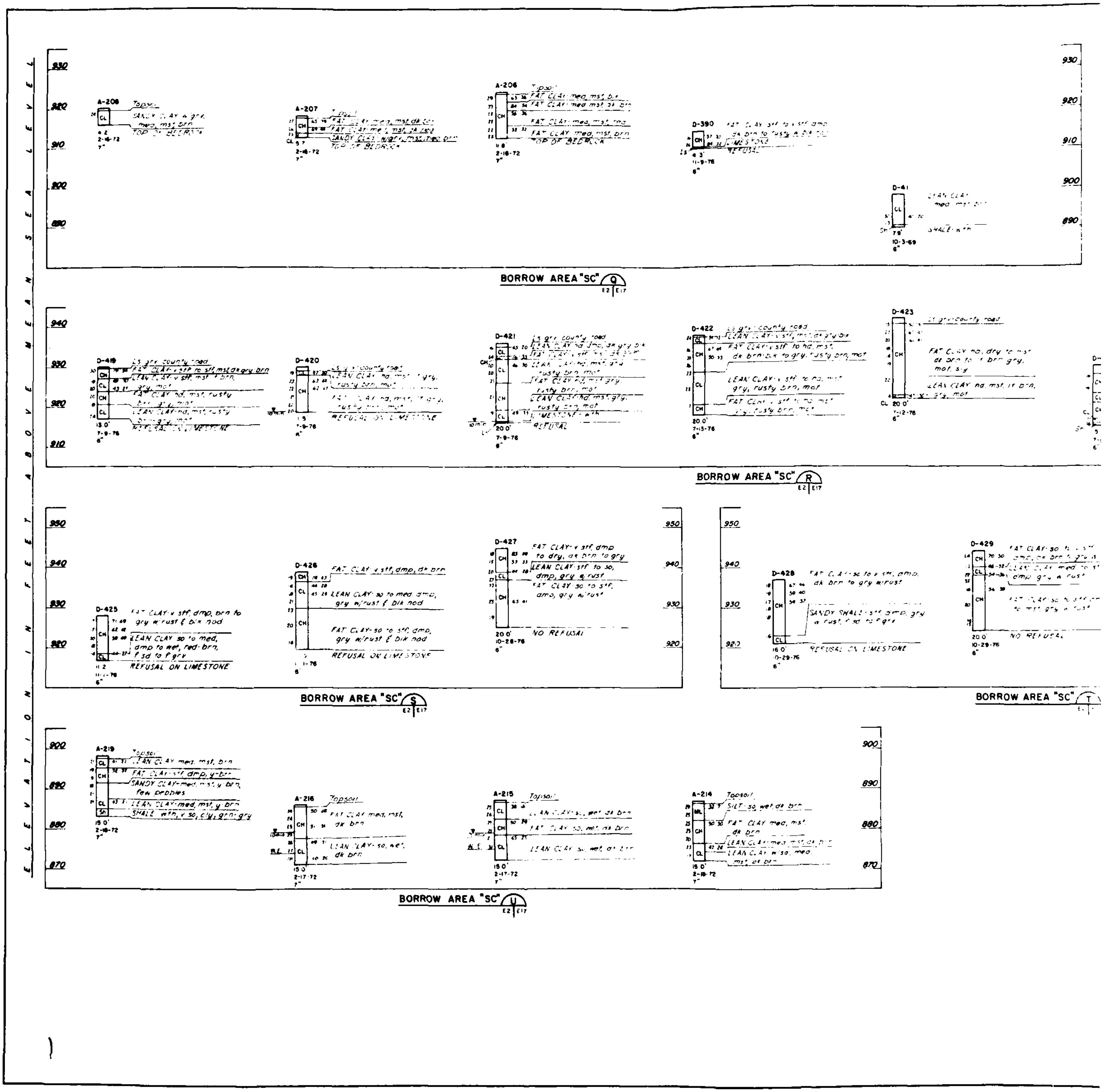
Dwg No E16
CORPS OF ENGINEERS
KANSAS CITY DISTRICT

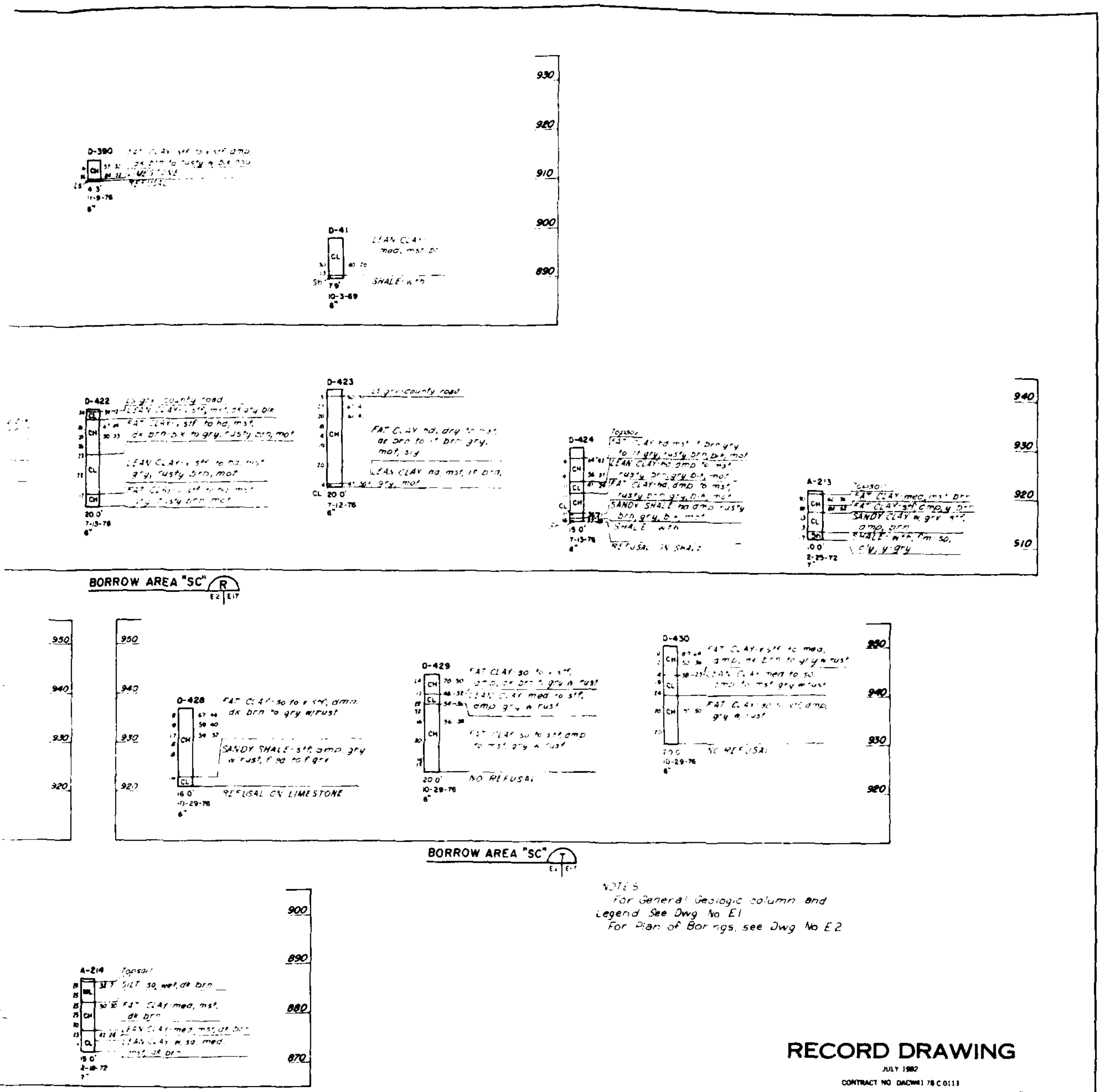
Scale as shown
U. S. ARMY
APRIL 1978

RECORD DRAWING
JULY 1982
CONTRACT NO. DACW41-78-C-0113

Submitted / Recommended / Approved
Compiled by M T M — Drawn by J PM — Checked by M T M

FILE NO 0-15-741


A-208
A-207
A-206
D-390
D-41
BORROW AREA "SC" Q
D-419
D-420
D-421
D-422
D-423
BORROW AREA "SC" R
D-425
D-426
D-427
D-428
D-429
BORROW AREA "SC" S
BORROW AREA "SC" T
A-219
A-216
A-215
A-214
BORROW AREA "SC" U



NOTES
For General Geologic column and Legend See Dwg No E1
For Plan of Borings, see Dwg No E2

RECORD DRAWING
JULY 1982
CONTRACT NO DACW41 78 C 0111

SYM	DESCRIPTION	DATE	APP'D
	Revised for "As Built" conditions		

REVISIONS

BIG BULL CREEK, KANSAS

HILLSDALE LAKE

STAGE III CONSTRUCTION

BORROW AREA
LOGS OF EXPLORATIONS

Dwg No E-7
CORPS OF ENGINEERS
KANSAS CITY DISTRICT

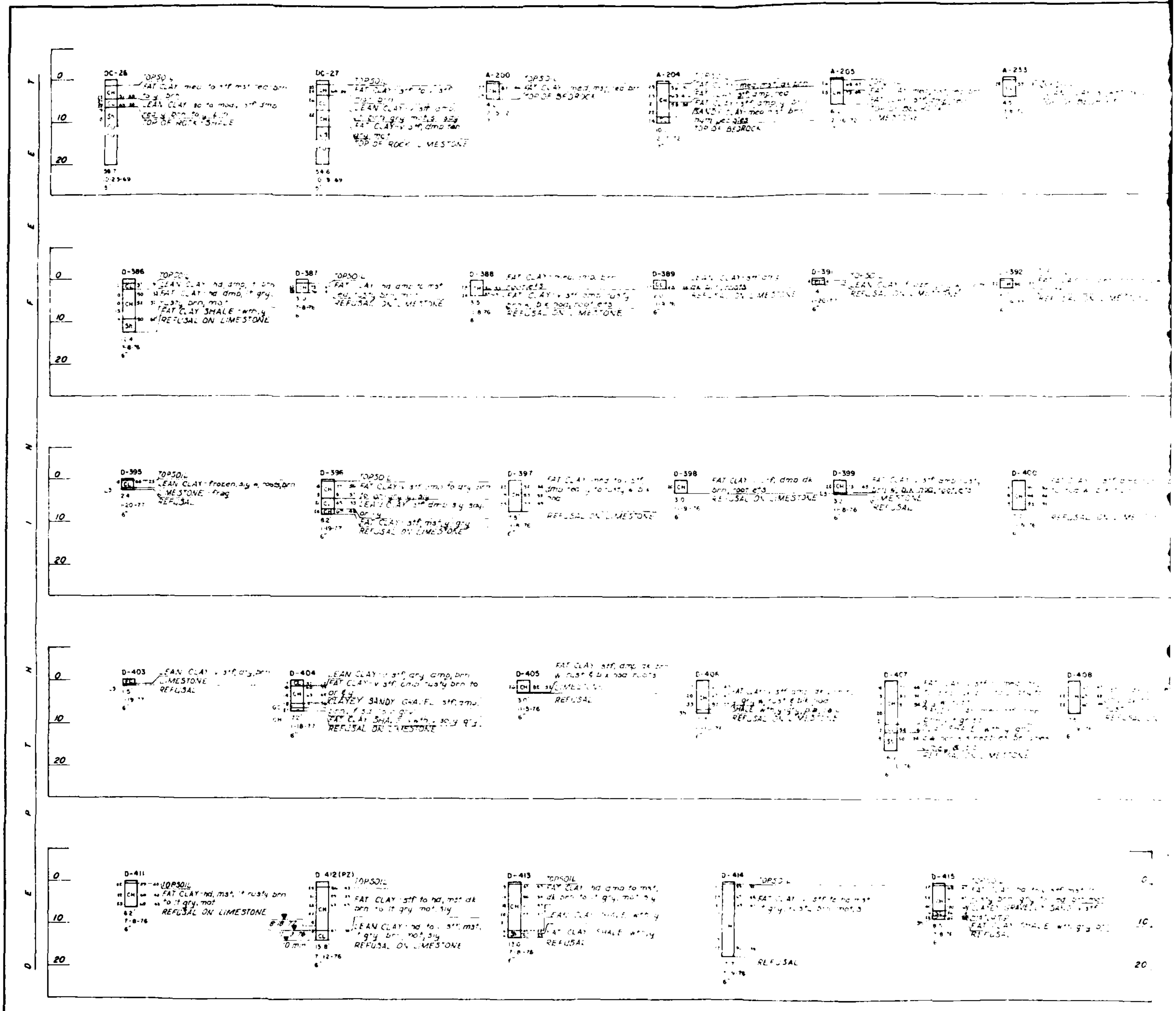
Scale as shown
U. S. ARMY
APRIL 1978

Submitted: CHIEF, DAMS & FOUNDATIONS SECT
Recommended: CHIEF, FOUNDATIONS & MATLS BR
Approved: CHIEF, ENGINEERING DIVISION

COMPILED BY M T M
DRAWN BY W L C
CHECKED BY R G F

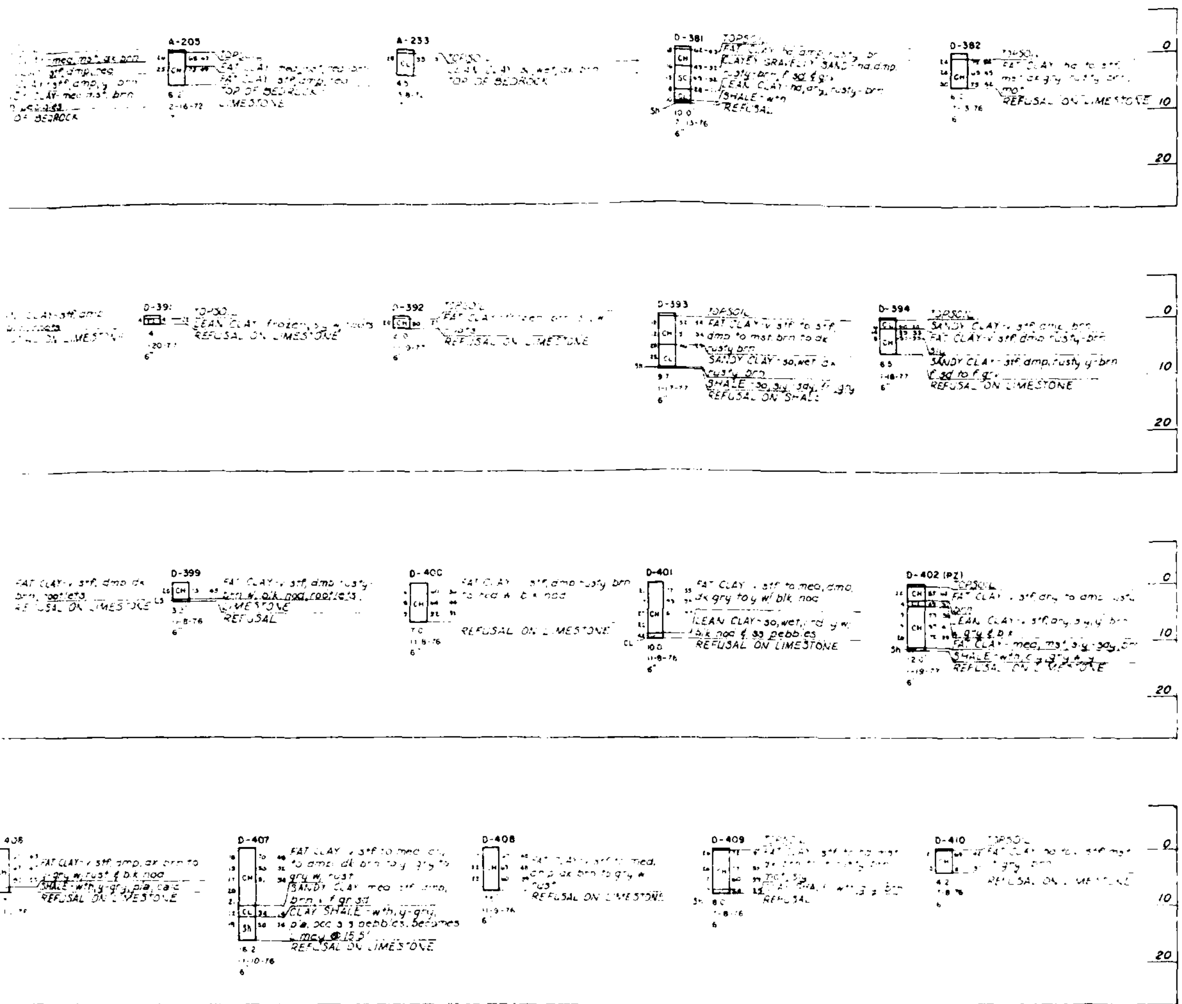
FILE NO 0-15-742

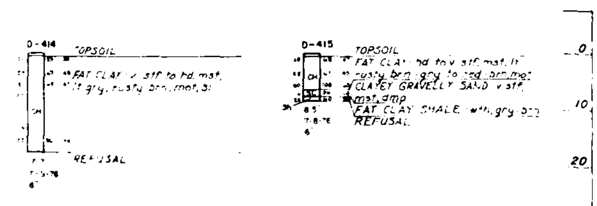
PLATE NO. 32



DC-28
TOPSOIL
TOP OF ROCK - SHALE
DC-27
TOPSOIL
TOP OF ROCK - LIMESTONE
A-200
TOP OF BEDROCK
A-204
TOP OF BEDROCK
A-205
A-233
D-386
TOPSOIL
FAT CLAY SHALE
REFUSAL ON LIMESTONE
D-387
TOPSOIL
REFUSAL ON LIMESTONE
D-388
FAT CLAY
REFUSAL ON LIMESTONE
D-389
D-391
D-392
D-395
TOPSOIL
LEAN CLAY - frozen
LIMESTONE - frag
REFUSAL
D-396
TOPSOIL
REFUSAL ON LIMESTONE
D-397
FAT CLAY
REFUSAL ON LIMESTONE
D-398
REFUSAL ON LIMESTONE
D-399
LIMESTONE
REFUSAL
D-400
D-403
LIMESTONE
REFUSAL
D-404
CLAYEY SANDY GRAVEL
REFUSAL ON LIMESTONE
D-405
LIMESTONE
REFUSAL
D-406
D-407
D-408
D-411
TOPSOIL
REFUSAL ON LIMESTONE
D-412 (PZ)
TOPSOIL
FAT CLAY
LEAN CLAY
REFUSAL ON LIMESTONE
D-413
TOPSOIL
FAT CLAY
REFUSAL
D-414
TOPSOIL
REFUSAL
D-415
TOPSOIL
FAT CLAY SHALE
REFUSAL
0
10
20

RECORD DRAW





Revised for "As Built" conditions

SYM | DESCRIPTION | DATE | APP'D

REVISIONS

BIG BULL CREEK, KANSAS

HILLSDALE LAKE

STAGE III CONSTRUCTION

BORROW AREA
LOGS OF EXPLORATIONS

Dwg No E18

CORPS OF ENGINEERS
KANSAS CITY DISTRICT

Scale: as shown

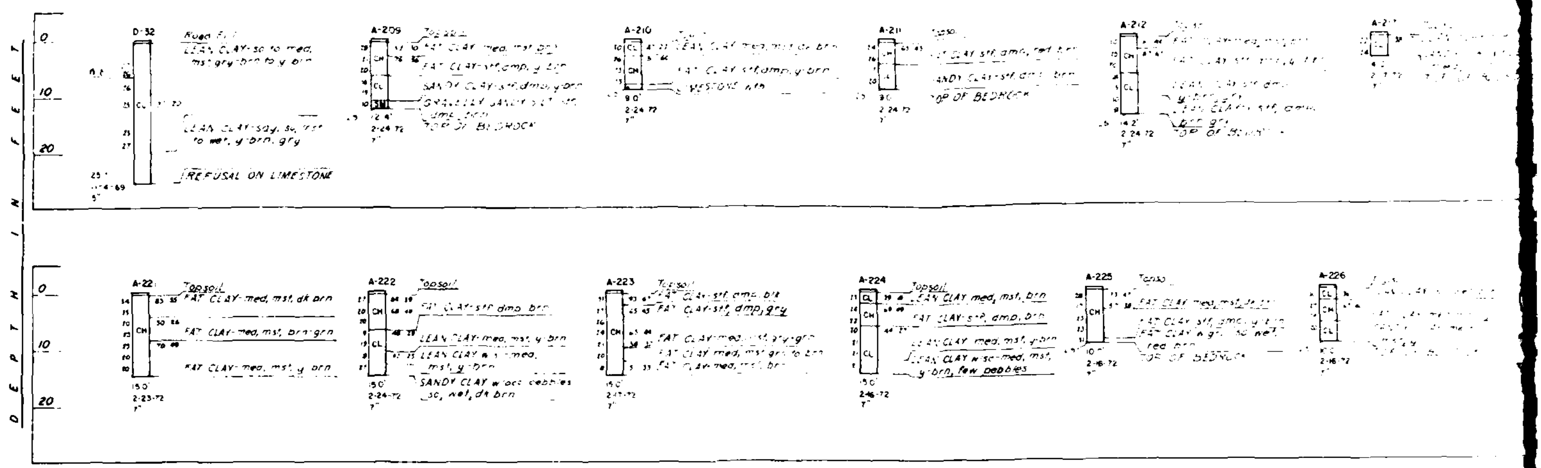
U S ARMY
APRIL 1978

Compiled by M T M · Drawn by J P M · Checked by M T M

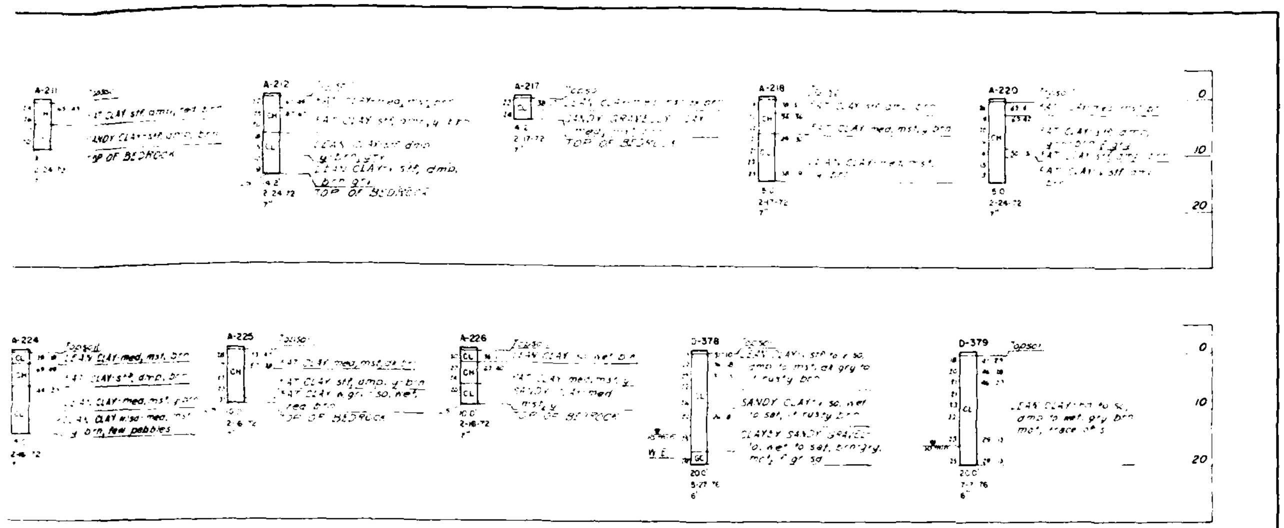
15-743

RECORD DRAWING

PLATE NO 33



DEPTH IN FEET
0
10
20
D-32
Road Fill
LEAN CLAY-sc to med, mst gry-brn to y brn
REFUSAL ON LIMESTONE
A-209
Topsoil
FAT CLAY-stf, dmp, y brn
TOP OF BEDROCK
2-24-72
A-210
A-211
TOP OF BEDROCK
A-212
A-221
Topsoil
FAT CLAY-med, mst, dk brn
FAT CLAY-med, mst, brn-grn
FAT CLAY-med, mst, y brn
15.0'
2-23-72
A-222
Topsoil
FAT CLAY-stf, dmp, brn
LEAN CLAY-med, mst, y brn
SANDY CLAY w/ occ pebbles sc, wet, dk brn
15.0'
2-24-72
A-223
Topsoil
FAT CLAY-stf, dmp, gry
A-224
Topsoil
LEAN CLAY-med, mst, brn
FAT CLAY-stf, dmp, brn
LEAN CLAY-med, mst, y-brn
LEAN CLAY w/ sc-med, mst, y-brn, few pebbles
15.0'
2-16-72
A-225
TOP OF BEDROCK
2-16-72
A-226



NOTES
For General Geologic Column and Legend See Dwg No E1
For Plan of Borings See Dwg No E2

RECORD DRAWING

JULY 1980

CONTRACT NO DACW41-78-C-

Revised to "As Built" conditions

SYM	DESCRIPTION	DATE	APP'D

REVISIONS

BIG BULL CREEK, KANSAS

HILLSDALE LAKE

STAGE III CONSTRUCTION

BORROW AREA
LOGS OF EXPLORATIONS

Dwg No E19
CORPS OF ENGINEERS
KANSAS CITY DISTRICT

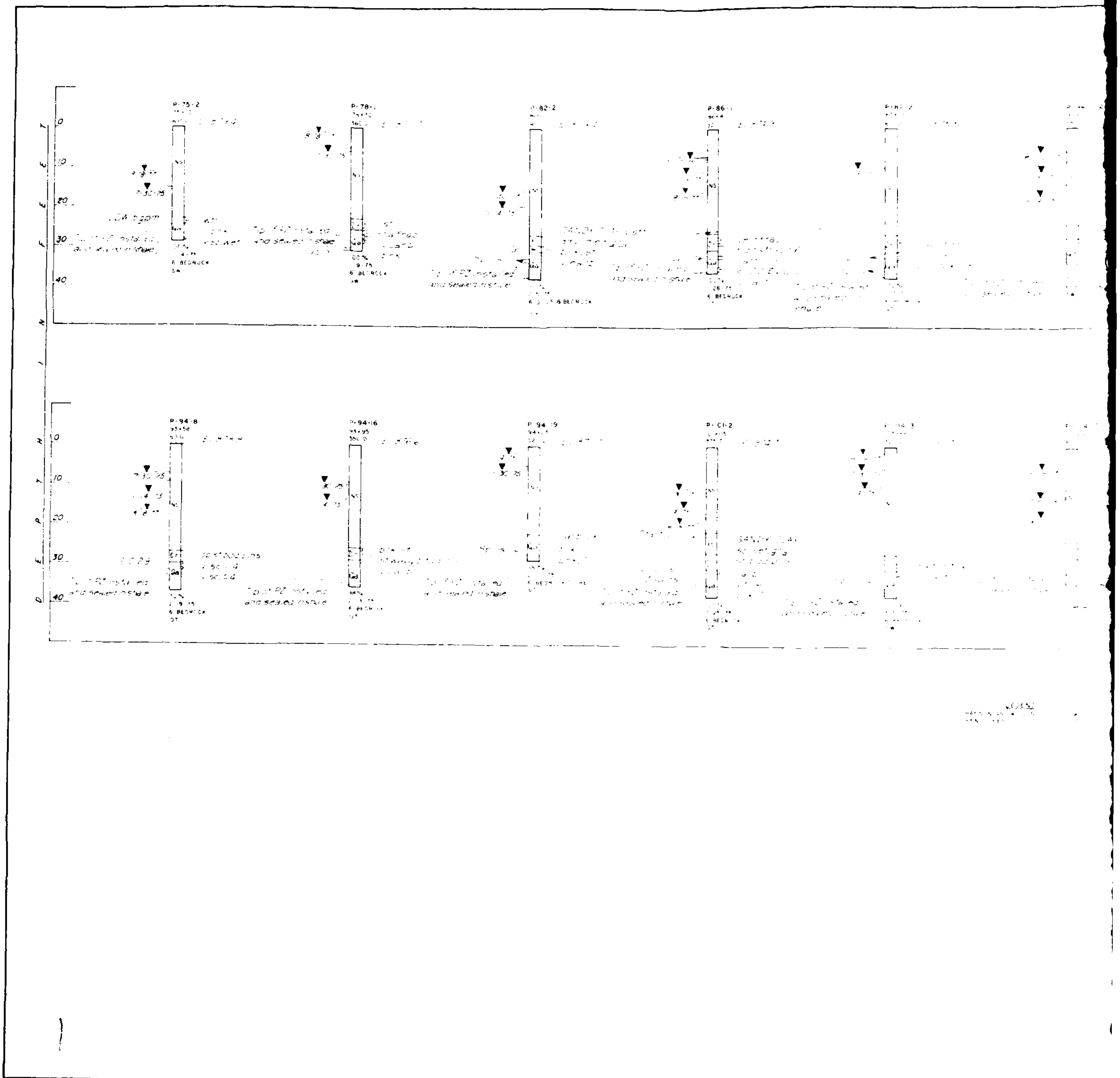
Scale as shown
U. S. ARMY
APRIL 1978

Submitted
Recommended
Approved

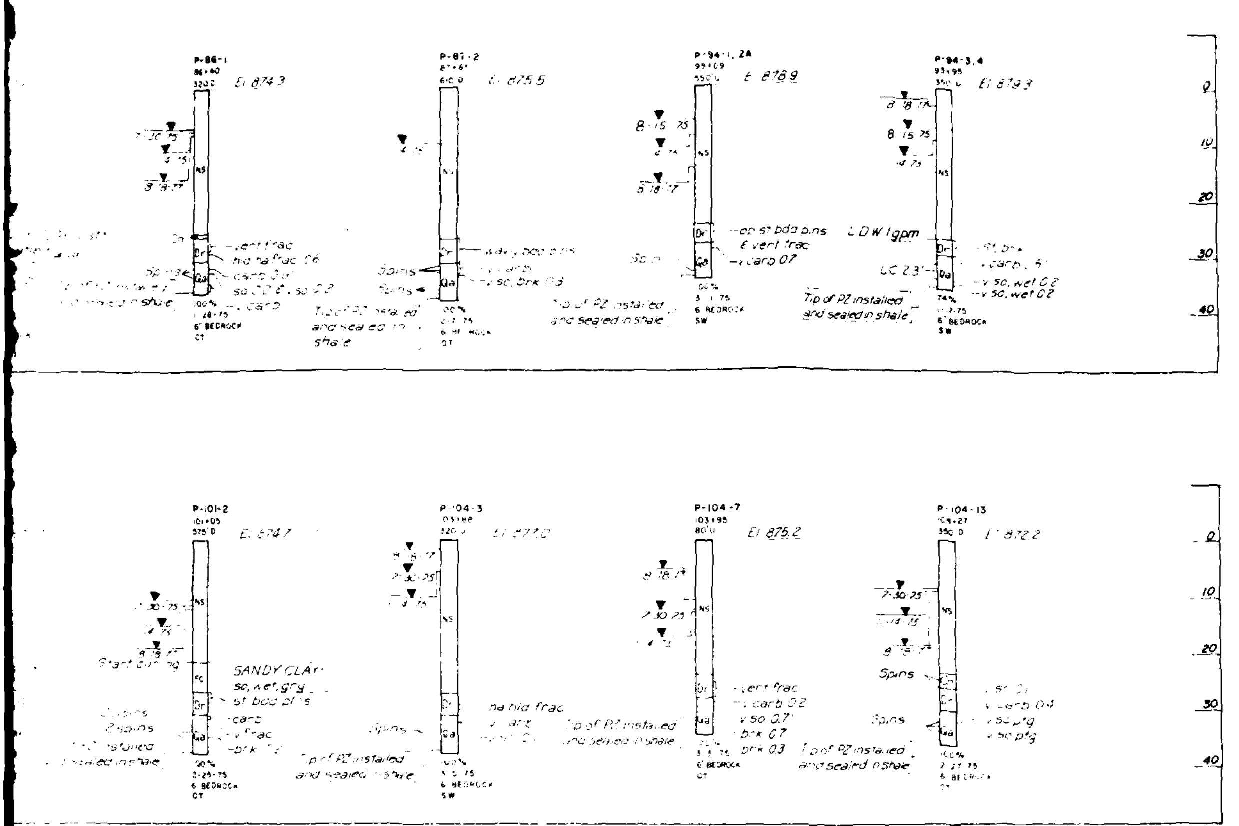
COMPILED BY M T M
DRAWN BY P M
CHECKED BY M T M

FILE NO 0-15-744

PLATE NO 34



DEPTH IN FEET
P-75-2
P-78-1
P-82-2
P-86-1
P-94-8
P-94-16
P-94-19
0
10
20
30
40
6' BEDROCK
Tip of PZ installed and sealed in shale
SANDY CLAY



LEGEND

SHANNON AND WILSON CELLS SW
OPEN TUBES OT

Notes
For General Bedrock Column and Legend See Dwg No E
For Plan of Borings, See Dwg No E2

RECORD DRAWING

JULY 1982
CONTRACT NO. DACW41 78 C 0111

Revised for As-Built conditions

SYM DESCRIPTION DATE APP'D

REVISIONS

BIG BULL CREEK, KANSAS

HILLSDALE LAKE

STAGE III CONSTRUCTION

LOGS OF BORING FOR EXISTING PIEZOMETERS

Dwg No E20
CORPS OF ENGINEERS
KANSAS CITY DISTRICT

Scale: as shown
U. S. ARMY
APRIL 1978

Submitted
CHIEF, GEOLOGY SECTION

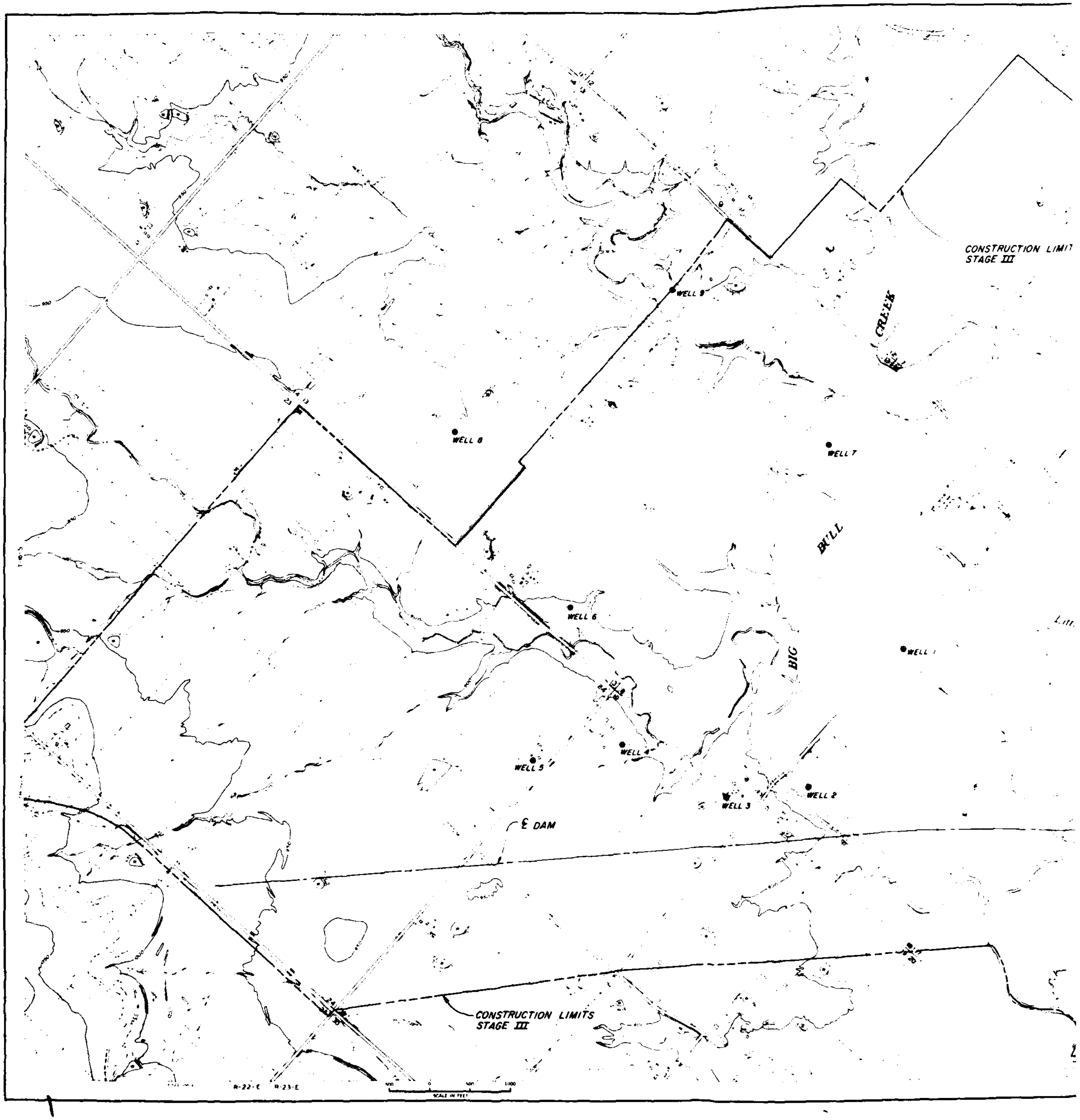
Recommended
CHIEF, FOUNDATIONS & MATLS. BR.

Approved
CHIEF, ENGINEERING DIVISION

COMPILED BY R.G.S. DRAWN BY CHECKED BY R.G.S./R.G.F.

FILE NO. 0-15-745

PLATE NO. 35


CONSTRUCTION LIMIT
STAGE III
WELL 9
CREEK
WELL 8
WELL 7
BULL
WELL 6
WELL 1
BIG
WELL 4
WELL 5
WELL 2
WELL 3
℄ DAM
CONSTRUCTION LIMITS
STAGE III
R-22-E
R-23-E
SCALE IN FEET

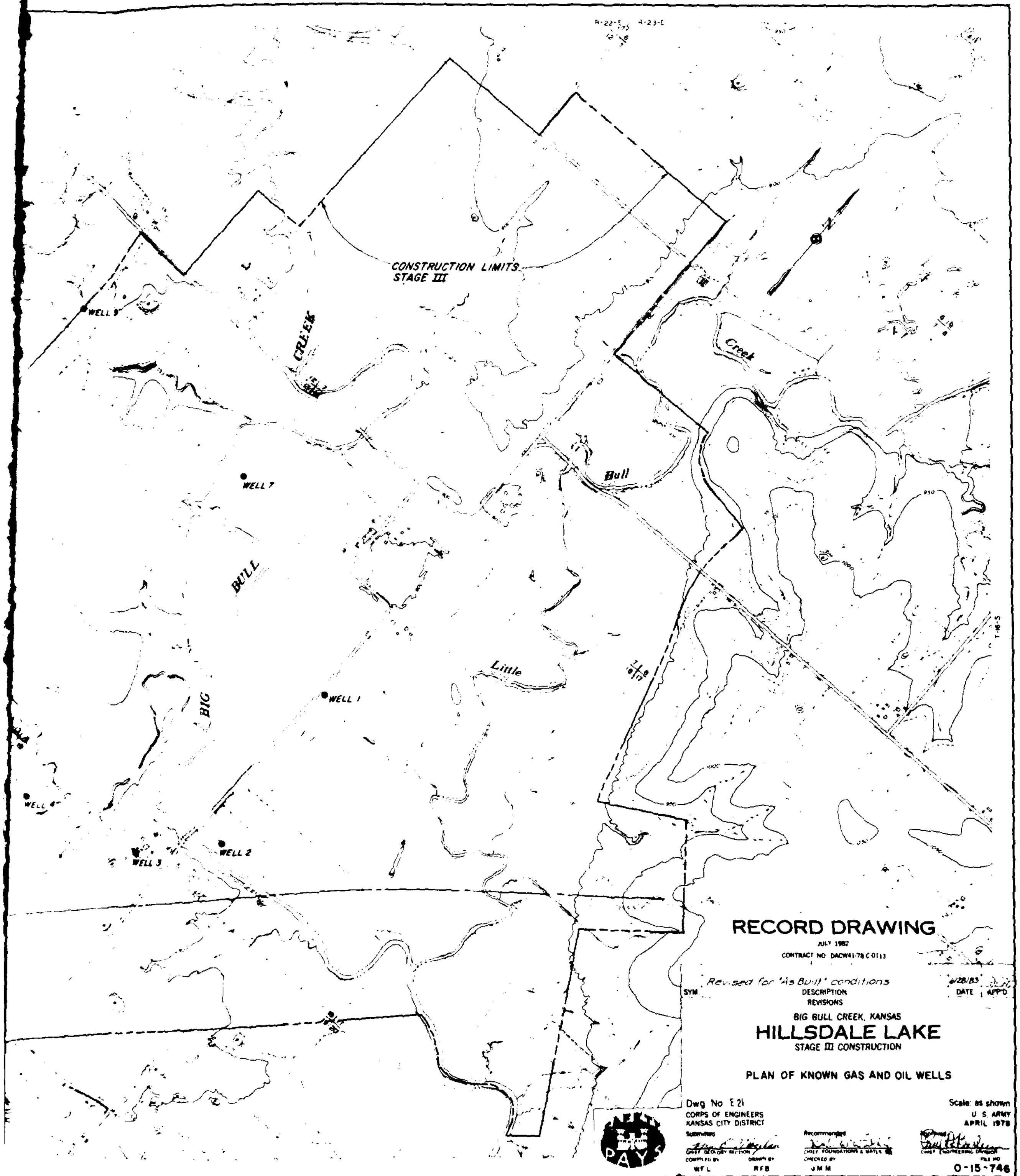
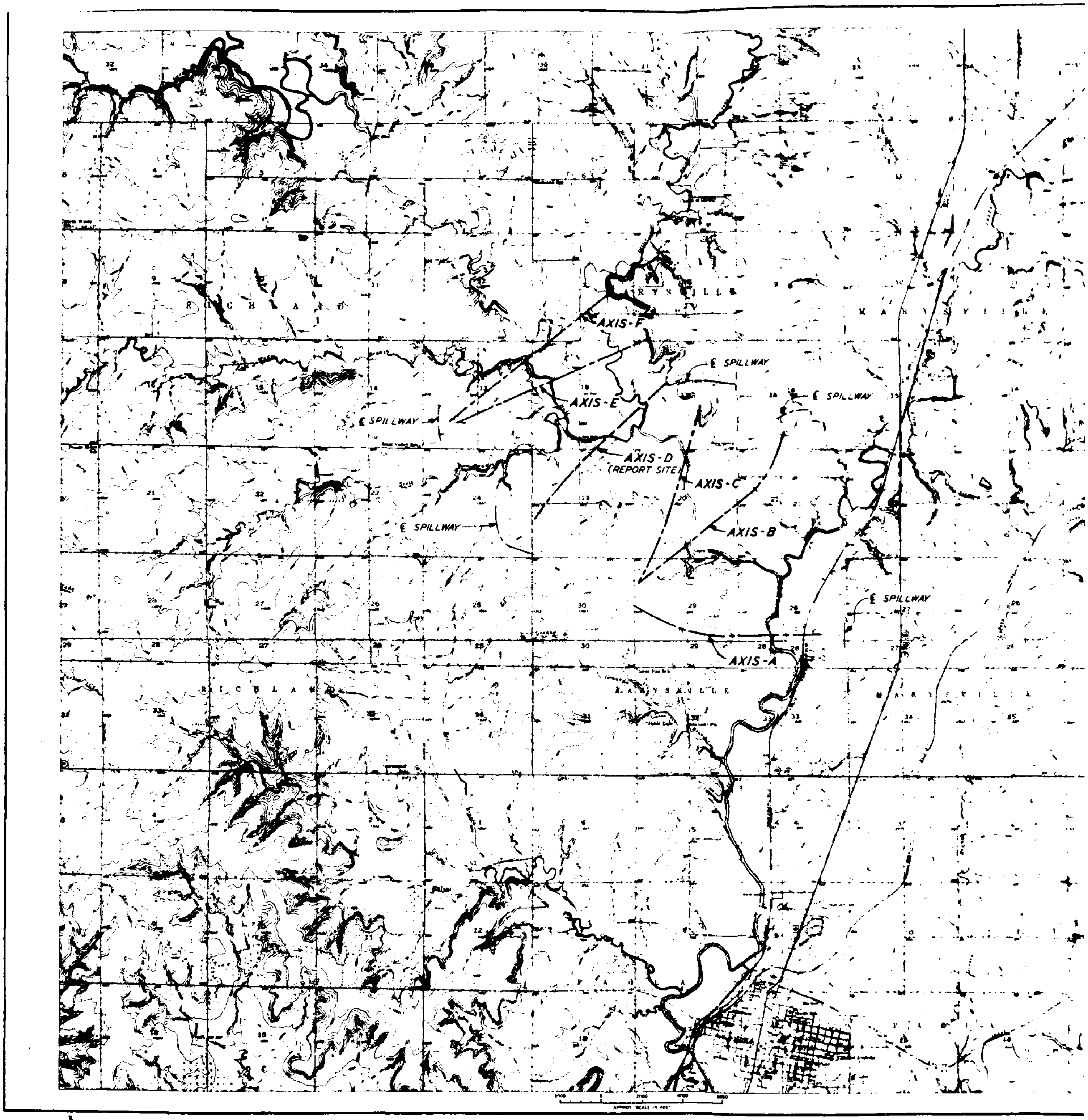
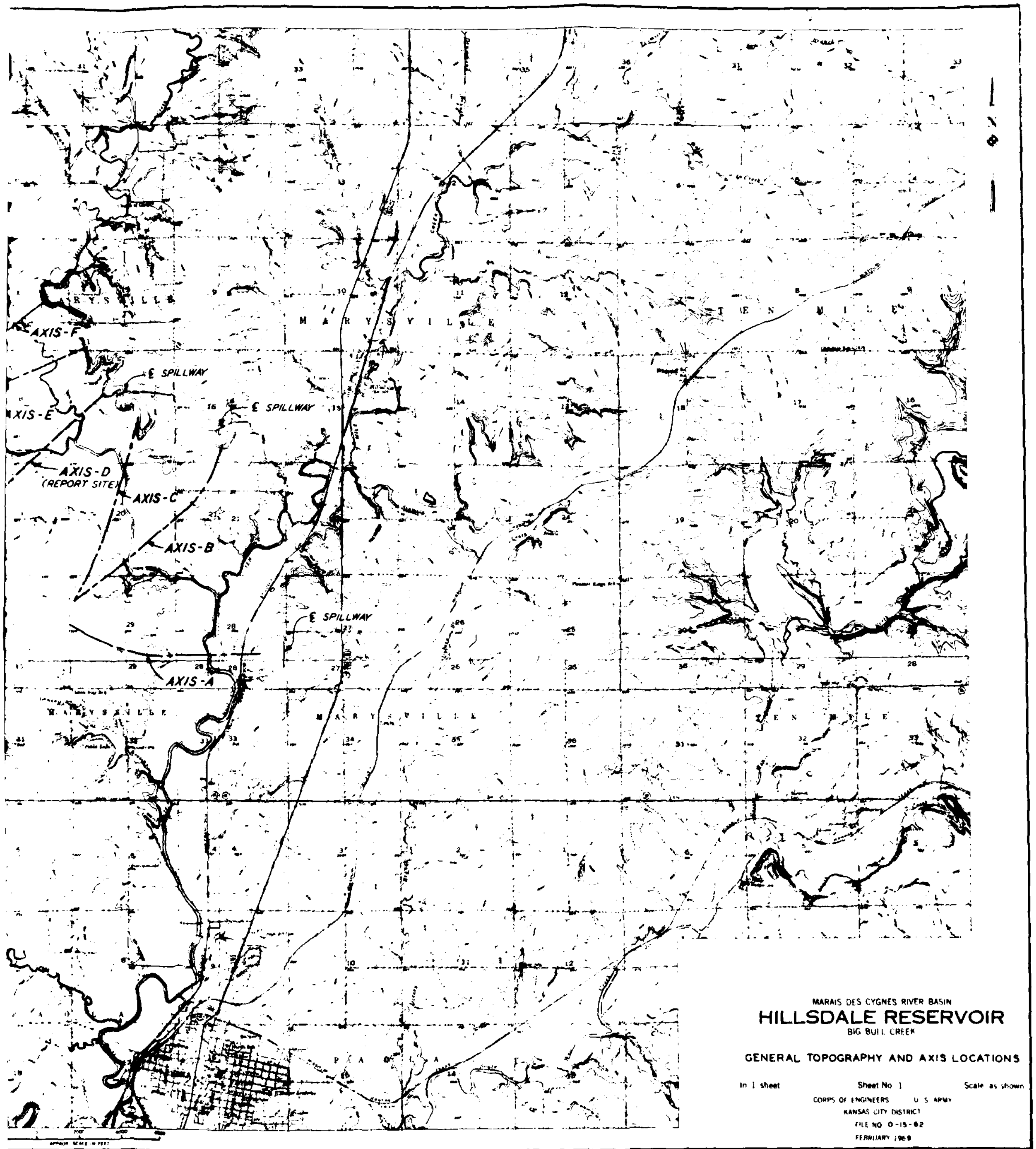

CONSTRUCTION LIMITS
STAGE III
CREEK
BULL
BIG
Creek
Bull
Little
WELL 9
WELL 7
WELL 1
WELL 4
WELL 2
WELL 3
RECORD DRAWING
JULY 1982
CONTRACT NO DACW41-78-C-0113
Revised for 'As Built' conditions
6/28/83
SYM
DESCRIPTION
DATE
APP'D
REVISIONS
BIG BULL CREEK, KANSAS
HILLSDALE LAKE
STAGE III CONSTRUCTION
PLAN OF KNOWN GAS AND OIL WELLS
Dwg No E 21
Scale: as shown
CORPS OF ENGINEERS
KANSAS CITY DISTRICT
U. S. ARMY
APRIL 1978
Submitted
Recommended
Approved
CHIEF GEOLOGY SECTION
CHIEF FOUNDATIONS & MATLS BR
CHIEF ENGINEERING DIVISION
COMPILED BY
DRAWN BY
CHECKED BY
FILE NO
WFL
RFB
JMM
0-15-746

PLATE NO. 36



AXIS-F
AXIS-E
AXIS-D
(REPORT SITE)
AXIS-C
AXIS-B
AXIS-A
℄ SPILLWAY
℄ SPILLWAY
℄ SPILLWAY
℄ SPILLWAY
℄ SPILLWAY
RICHLAND
MARYSVILLE
APPROX SCALE IN FEET



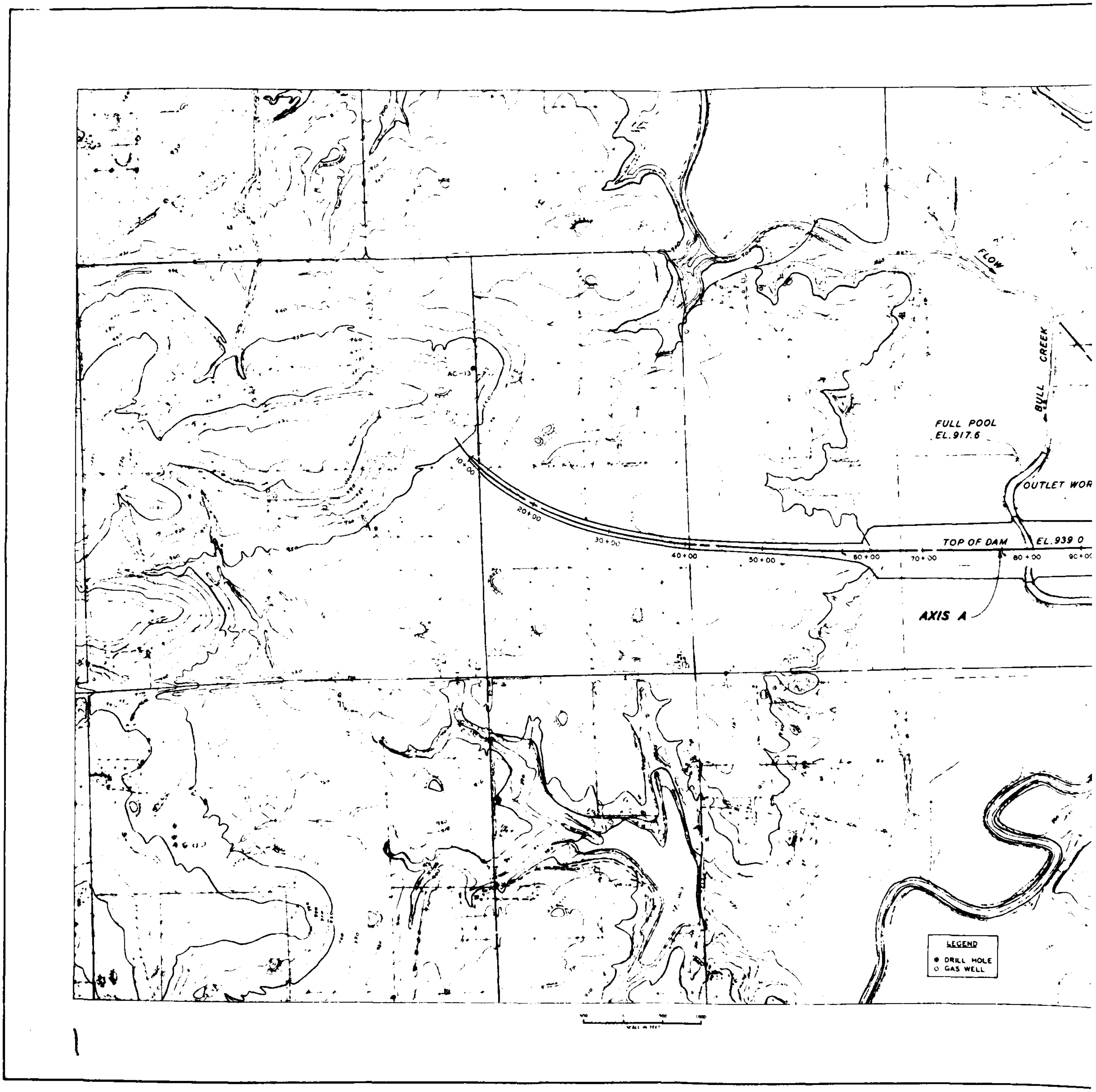
MARAIS DES CYGNES RIVER BASIN
HILLSDALE RESERVOIR
BIG BULL CREEK

GENERAL TOPOGRAPHY AND AXIS LOCATIONS

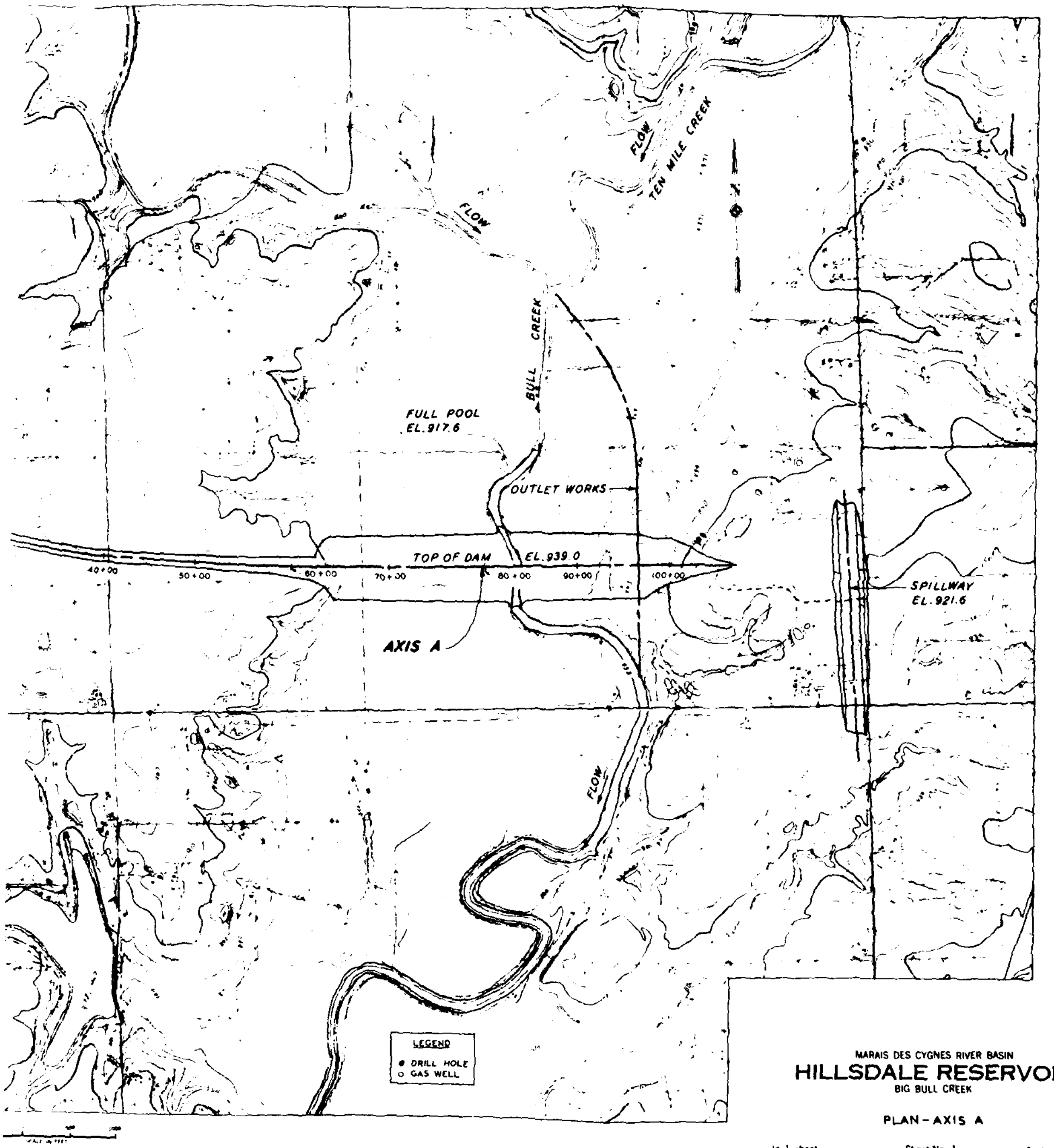
In 1 sheet   Sheet No. 1   Scale as shown

CORPS OF ENGINEERS   U. S. ARMY
KANSAS CITY DISTRICT
FILE NO. O-15-82
FEBRUARY 1969

PLATE NO 37



FLOW
BULL CREEK
FULL POOL EL. 917.6
OUTLET WOR
TOP OF DAM
EL. 939 0
AXIS A
AC-13
10+00
20+00
30+00
40+00
50+00
60+00
70+00
80+00
LEGEND
DRILL HOLE
GAS WELL



MARAIS DES CYGNES RIVER BASIN

HILLSDALE RESERVOIR

BIG BULL CREEK

PLAN - AXIS A

In 1 sheet | Sheet No. 1 | Scale: as shown

CORPS OF ENGINEERS U. S. ARMY

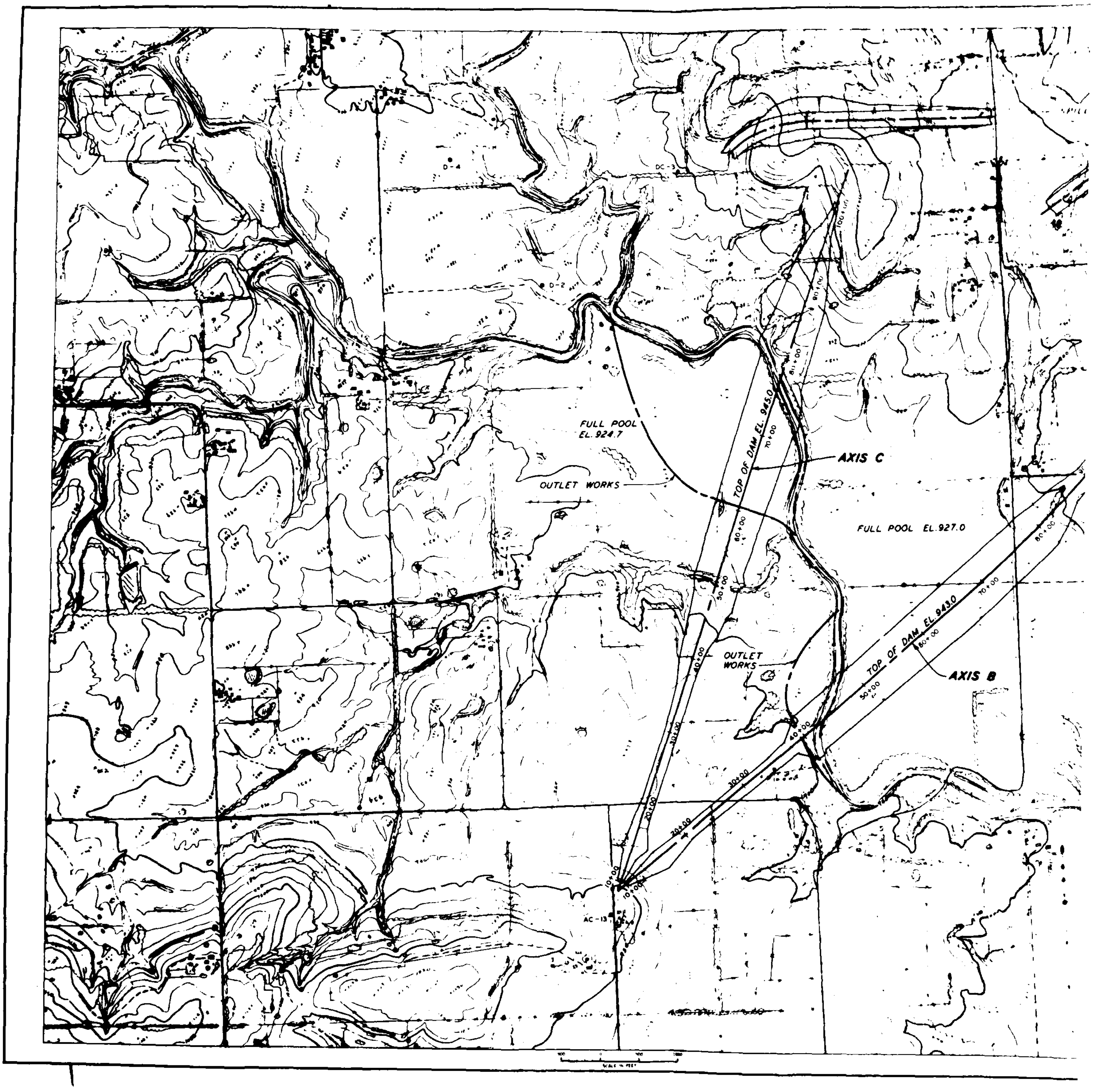
KANSAS CITY DISTRICT

FILE NO. O-15-83

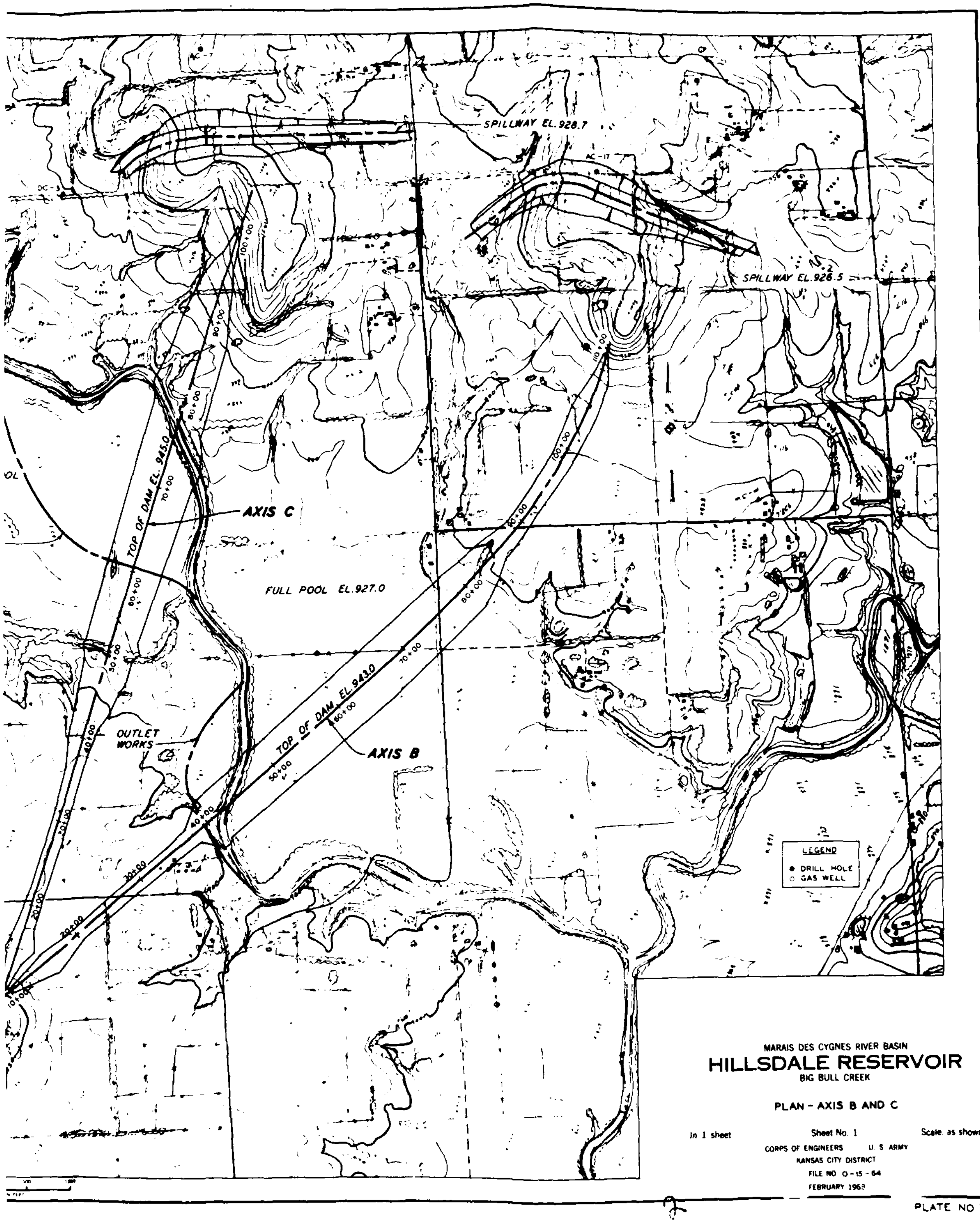
FEBRUARY 1969

2

PLATE NO. 38



FULL POOL
EL. 924.7
OUTLET WORKS
AXIS C
TOP OF DAM EL. 945.0
FULL POOL EL. 927.0
OUTLET
WORKS
TOP OF DAM EL. 943.0
AXIS B
D-4
D-2
DC-3
AC-13



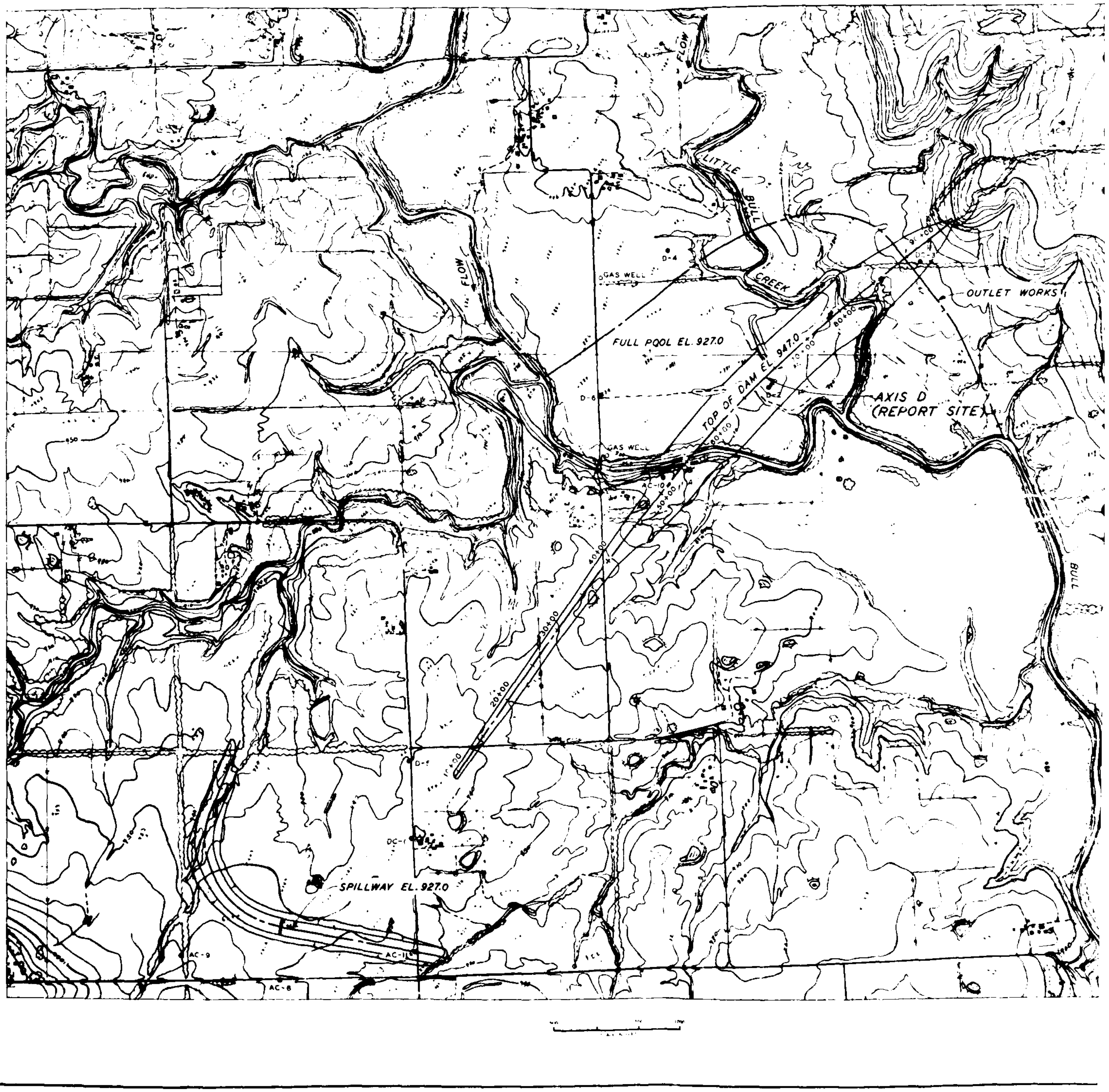
MARAIS DES CYGNES RIVER BASIN
HILLSDALE RESERVOIR
BIG BULL CREEK

PLAN - AXIS B AND C

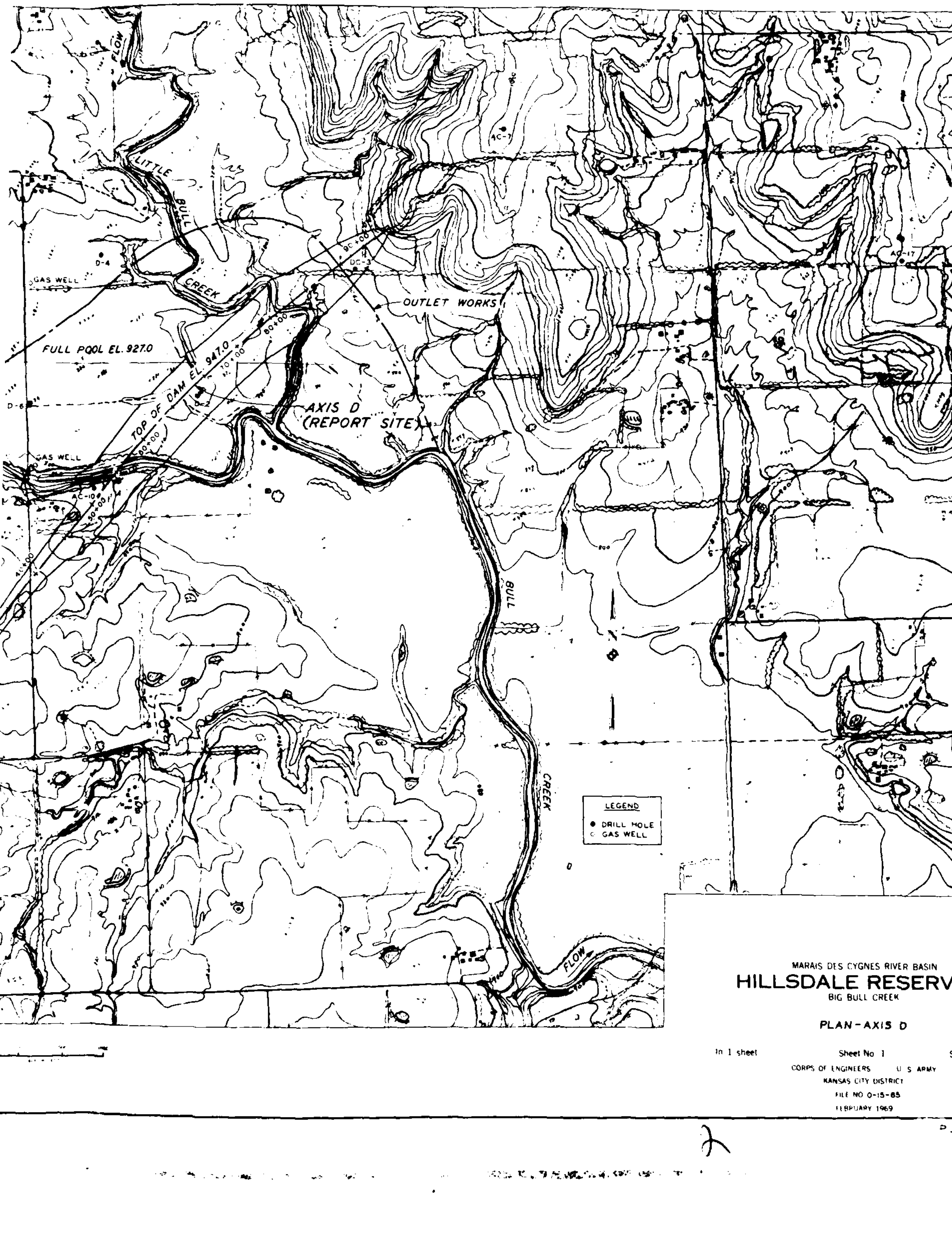
In 1 sheet | Sheet No. 1 | Scale: as shown

CORPS OF ENGINEERS U. S. ARMY
KANSAS CITY DISTRICT
FILE NO. O-15-64
FEBRUARY 1963

PLATE NO 39



FLOW
LITTLE BULL CREEK
FLOW
GAS WELL
D-4
OUTLET WORKS
FULL POOL EL. 927.0
TOP OF DAM EL. 947.0
AXIS D
(REPORT SITE)
D-6
GAS WELL
BULL
D-9
DC-1
SPILLWAY EL. 927.0
AC-9
AC-11
AC-8



MARAIS DES CYGNES RIVER BASIN

HILLSDALE RESERVOIR

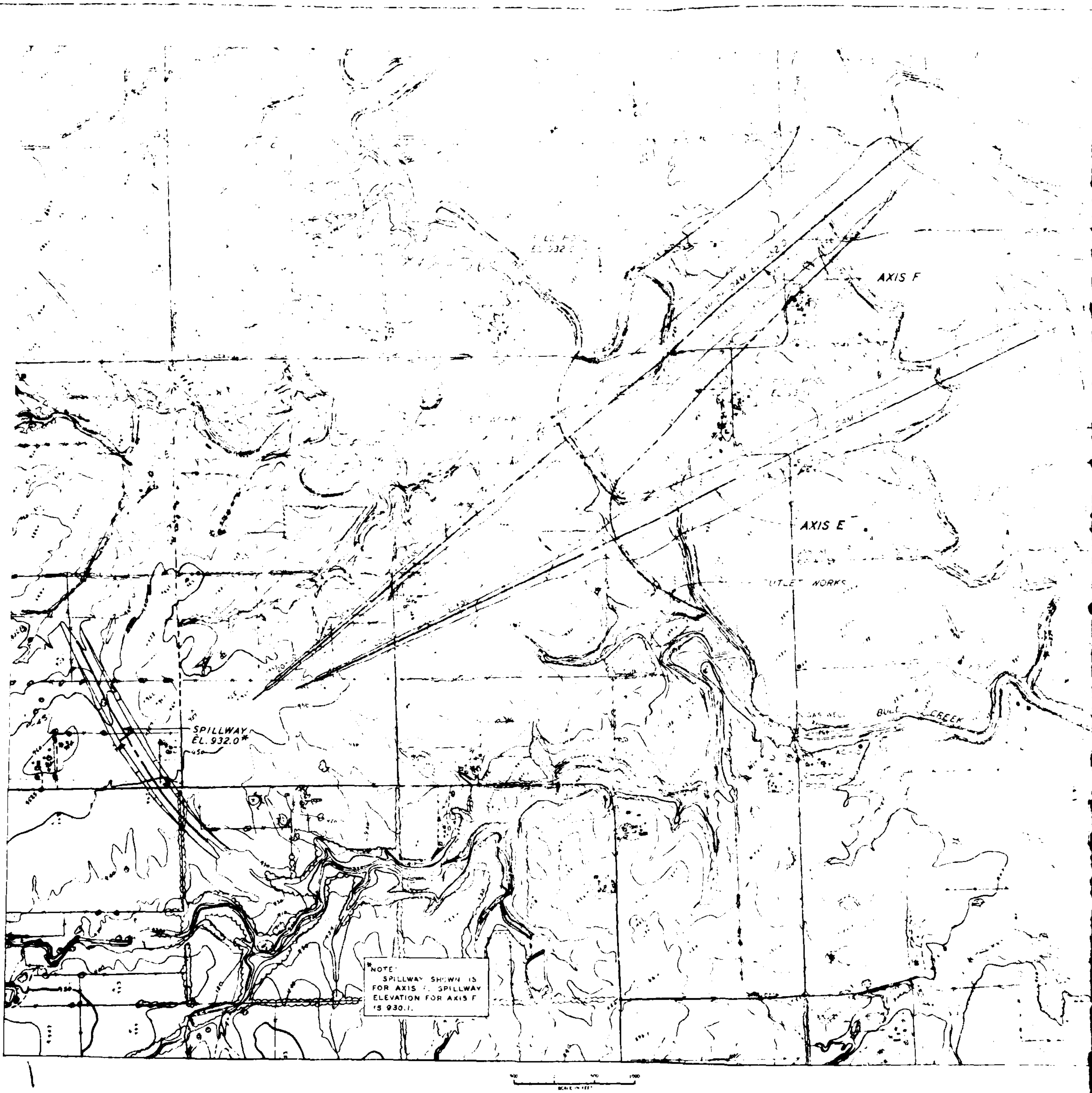
BIG BULL CREEK

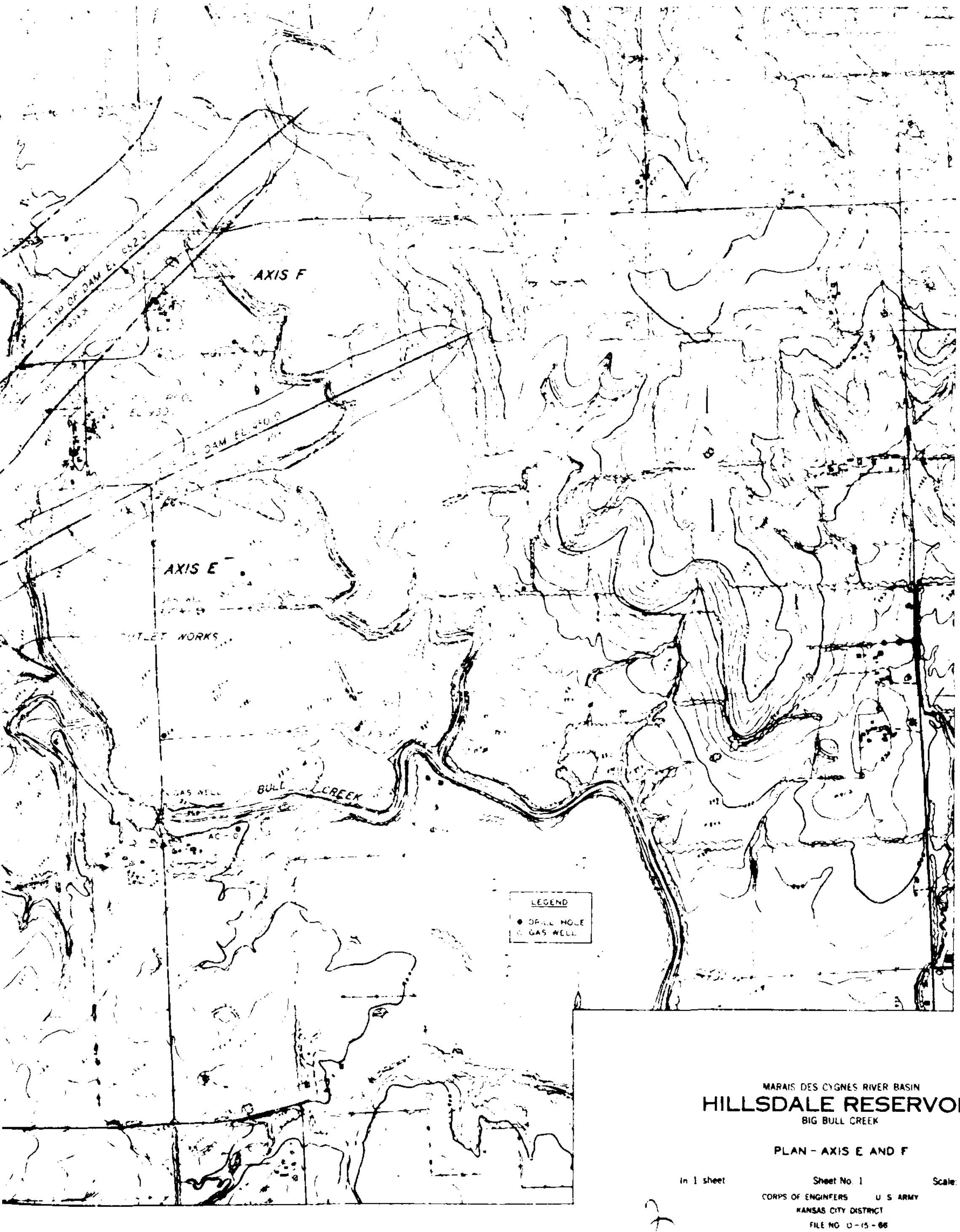
PLAN-AXIS D

In 1 sheet | Sheet No. 1 | Scale: as shown

CORPS OF ENGINEERS U. S. ARMY
KANSAS CITY DISTRICT
FILE NO. O-15-85
FEBRUARY 1969

PLATE NO 40


AXIS F
AXIS E
WORKS
SPILLWAY
EL. 932.0*
CREEK
*NOTE
SPILLWAY SHOWN IS FOR AXIS . SPILLWAY ELEVATION FOR AXIS F IS 930.1.



MARAIS DES CYGNES RIVER BASIN

HILLSDALE RESERVOIR

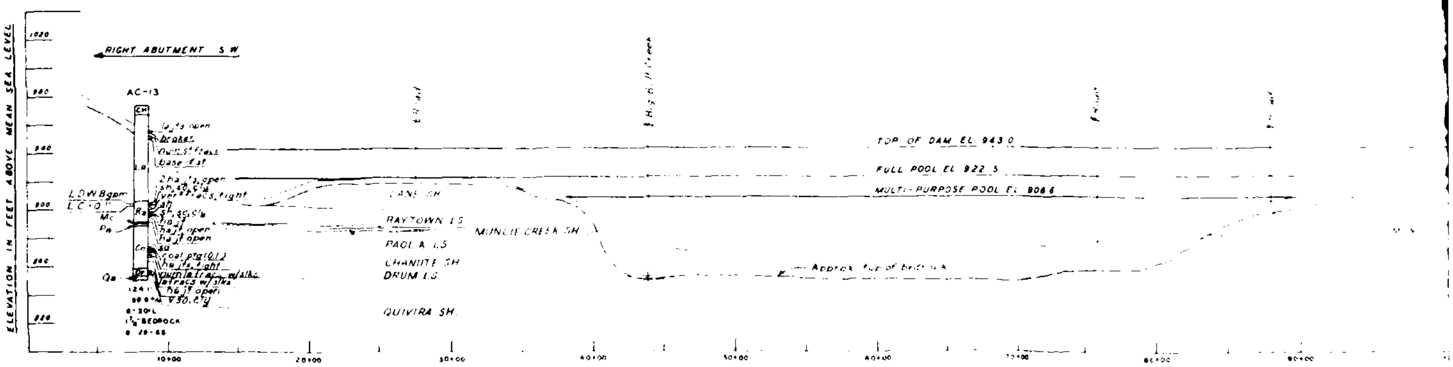
BIG BULL CREEK

PLAN - AXIS E AND F

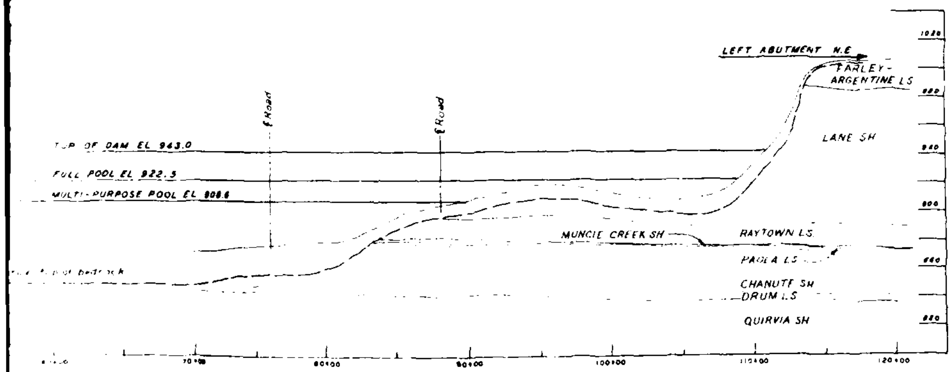
In 1 sheet | Sheet No. 1 | Scale: as shown

CORPS OF ENGINEERS U. S. ARMY
KANSAS CITY DISTRICT
FILE NO. O-15-66
FEBRUARY 1969

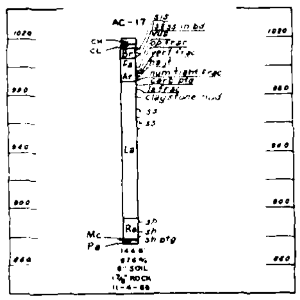
PLATE NO 41



GEOLOGIC PROFILE ALONG AXIS "B"



C PROFILE ALONG AXIS "B"



DETACHED BORING – SPILLWAY
AXIS "B"

MARAIS DES CYGNES RIVER BASIN
HILLSDALE RESERVOIR
BIG BULL CREEK

GEOLOGIC PROFILE
AXIS "B"

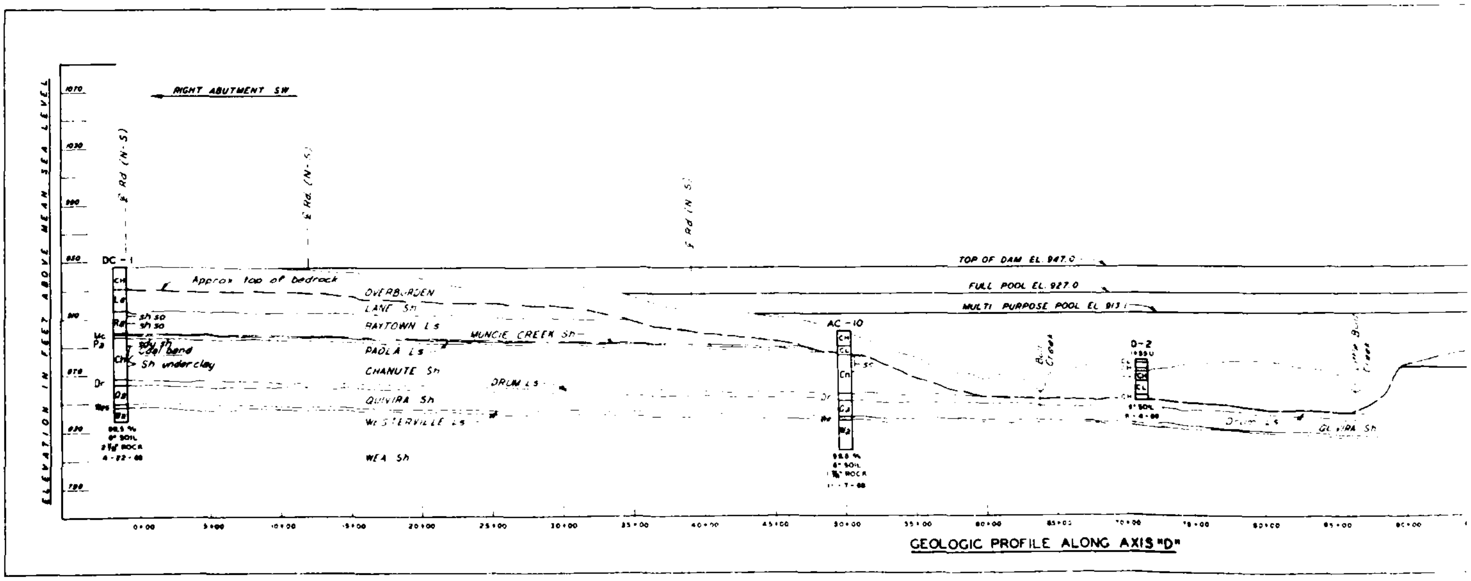
In 1 sheet Sheet No. 1 Scale as shown

CORPS OF ENGINEERS U. S. ARMY
KANSAS CITY DISTRICT

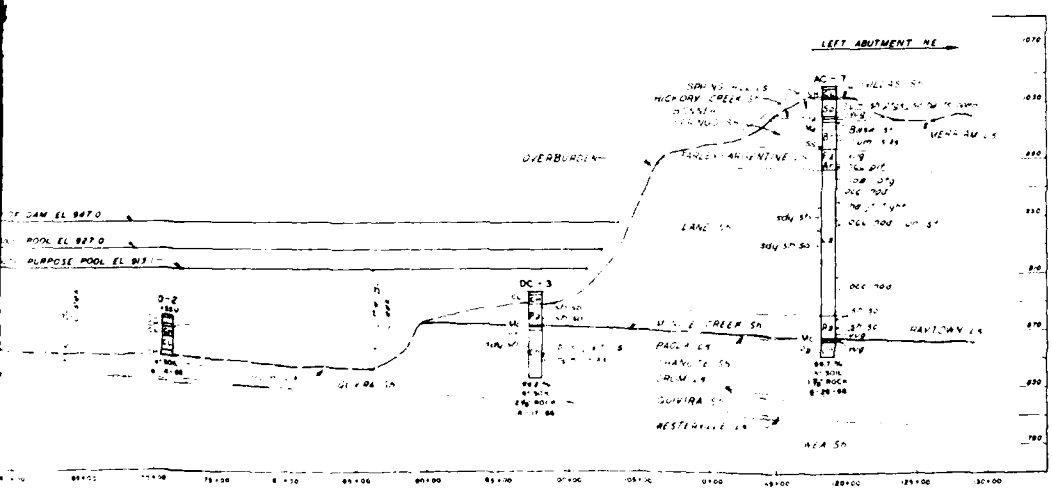
FILE NO. Q-15-68
FEBRUARY 1969

2

PLATE NO. 42



GEOLOGIC PROFILE ALONG AXIS "D"



C PROFILE ALONG AXIS "D"

MARAIS DES CYGNES RIVER BASIN
HILLSDALE RESERVOIR
BIG BULL CREEK

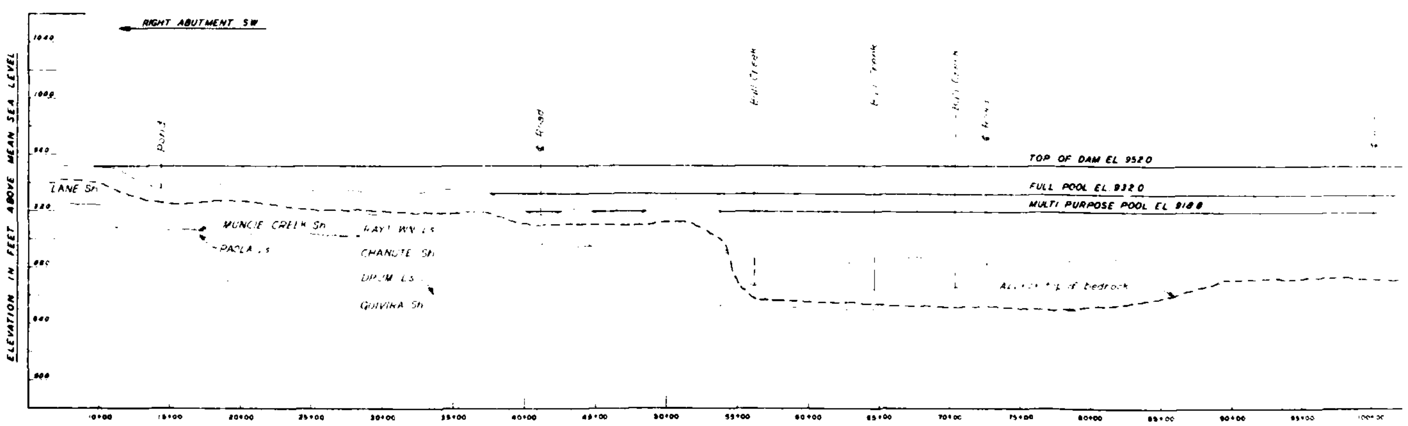
GEOLOGIC PROFILE
AXIS "D"

In 1 sheet | Sheet No 1 | Scale as shown

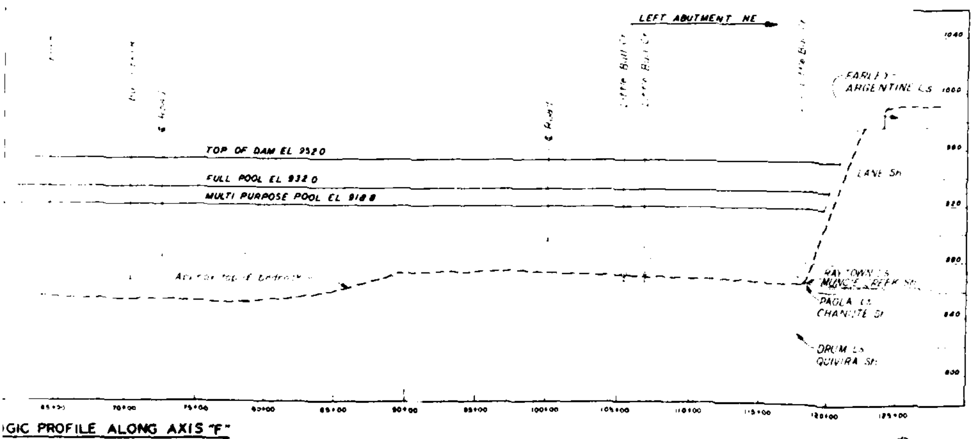
CORPS OF ENGINEERS U. S. ARMY
KANSAS CITY DISTRICT

FILE NO. D-15-88
FEBRUARY 1969

PLATE NO 43



GEOLOGIC PROFILE ALONG AXIS "F"



GIC PROFILE ALONG AXIS "F"

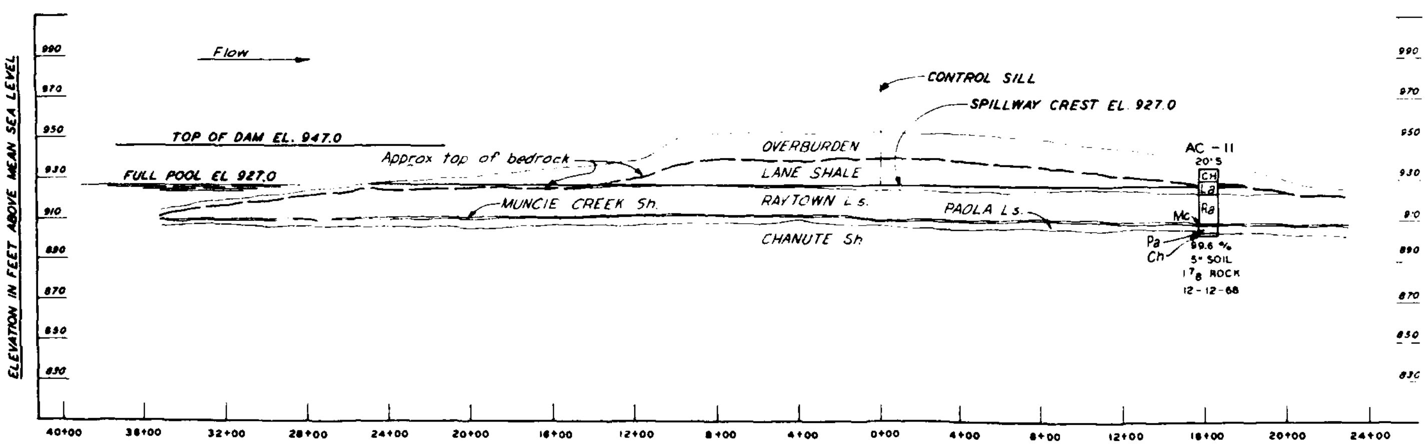
HILLSDALE RESERVOIR

GEOLOGIC PROFILE
AXIS

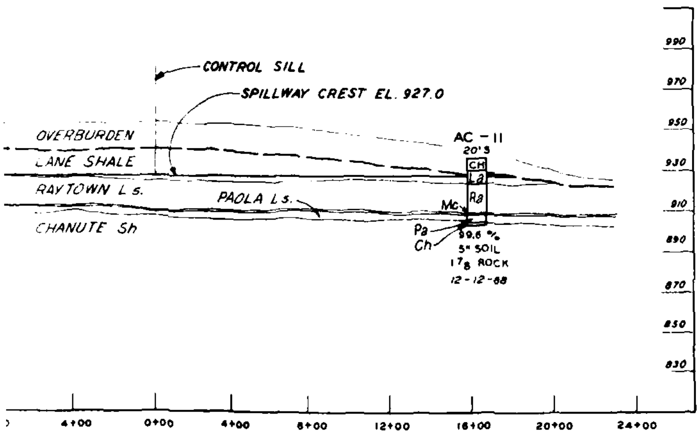
Sheet No. 1

Scale as shown

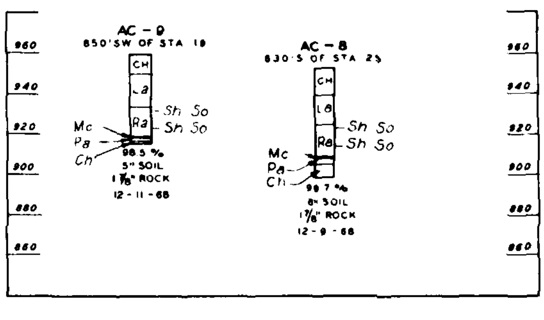
PLATE NO. 44



GEOLOGIC PROFILE ALONG CENTERLINE SPILLWAY AXIS "D"



ENTERLINE SPILLWAY AXIS "D"



DETACHED BORINGS - SPILLWAY

MARAIS DES CYGNES RIVER BASIN

HILLSDALE RESERVOIR

BIG BULL CREEK

GEOLOGIC PROFILE
SPILLWAY FOR AXIS "D"

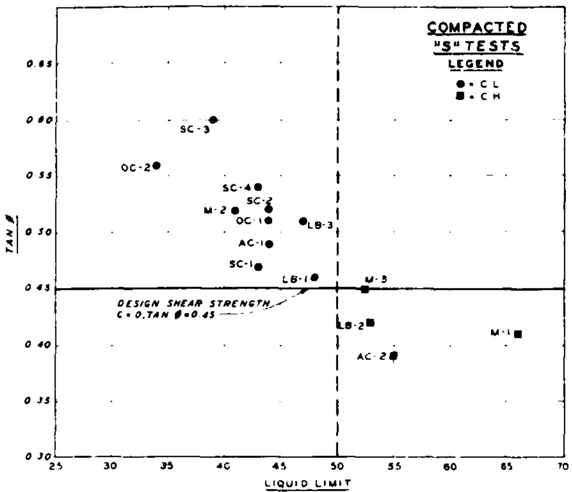
2

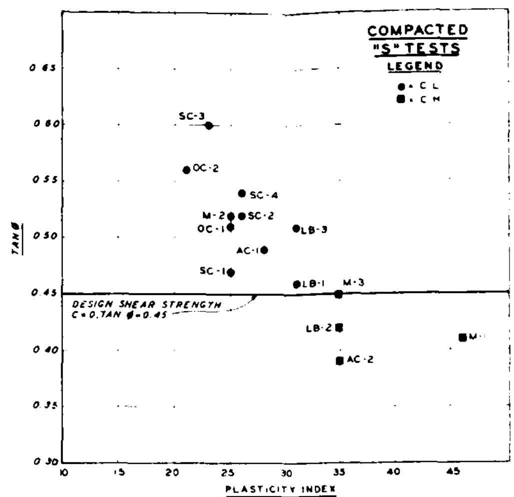
In 1 sheet Sheet No. 1 Scale as shown

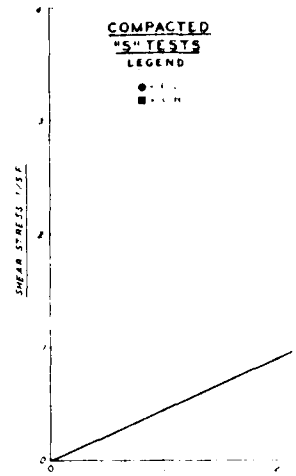
CORPS OF ENGINEERS U. S. ARMY
KANSAS CITY DISTRICT

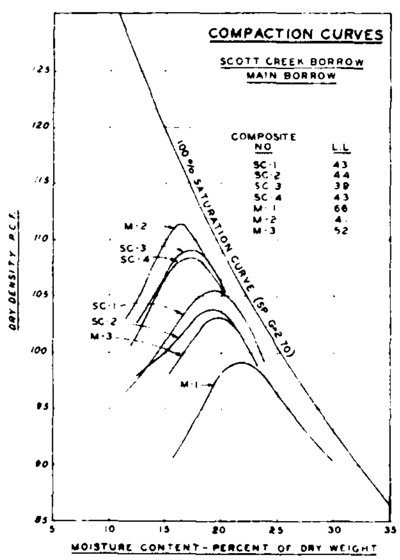
FILE NO. O-15-71
FEBRUARY 1969

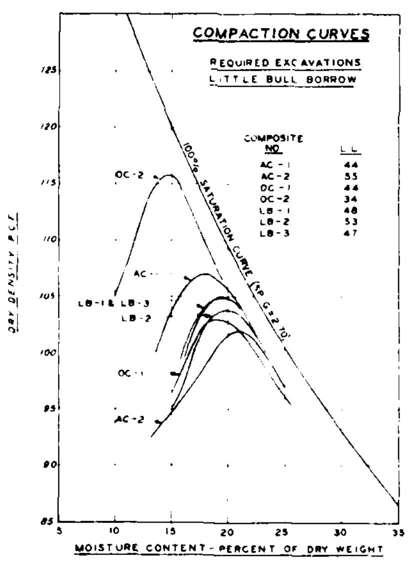
PLATE NO. 45

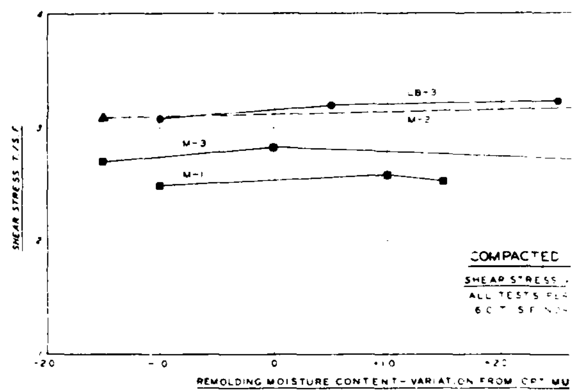

COMPACTED
"S" TESTS
LEGEND
● = C L
■ = C H
SC-3
OC-2
SC-4
SC-2
M-2
OC-1
LB-3
AC-1
SC-1
LB-1
M-3
DESIGN SHEAR STRENGTH
C = 0, TAN ø = 0.45
LB-2
AC-2
M-1
TAN ø
LIQUID LIMIT

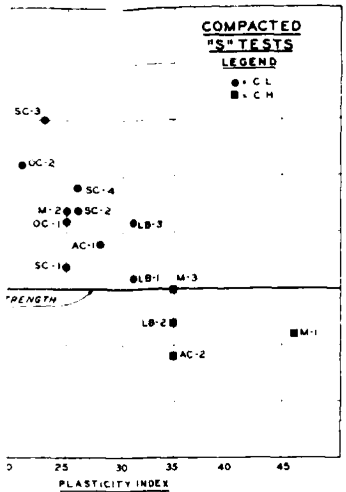

COMPACTED
"S" TESTS
LEGEND
● = C L
■ = C H
SC-3
OC-2
SC-4
M-2
SC-2
OC-1
LB-3
AC-1
SC-1
LB-1
M-3
DESIGN SHEAR STRENGTH
C = 0, TAN ø = 0.45
LB-2
AC-2
TAN ø
PLASTICITY INDEX

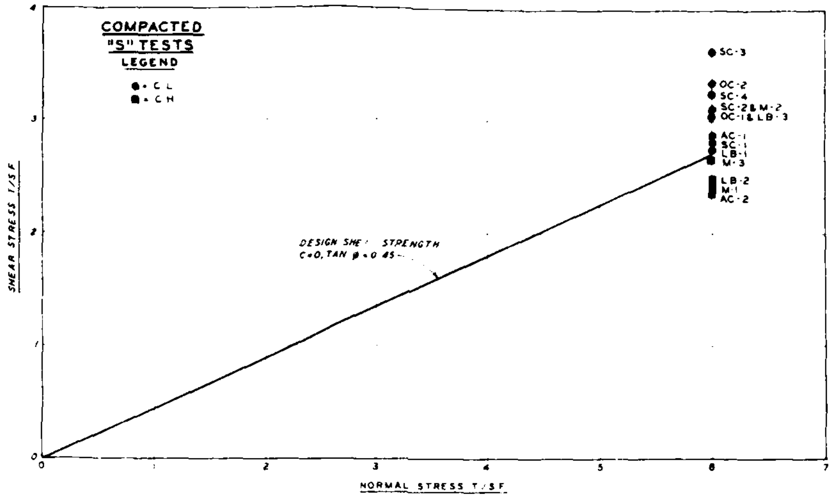

COMPACTED
"S" TESTS
LEGEND
SHEAR STRESS T/S.F.

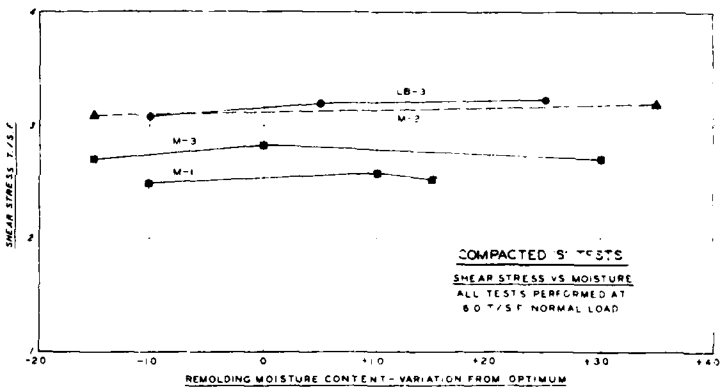

COMPACTION CURVES
SCOTT CREEK BORROW
MAIN BORROW
COMPOSITE NO
L.L.
SC-1 43
SC-2 44
SC-3 39
SC-4 43
M-1 66
M-3 52
100% SATURATION CURVE (SP. G=2.70)
M-2
SC-3
SC-4
SC-1
SC-2
M-3
M-1
DRY DENSITY P.C.F.
MOISTURE CONTENT - PERCENT OF DRY WEIGHT


COMPACTION CURVES
REQUIRED EXCAVATIONS
LITTLE BULL BORROW
COMPOSITE NO
L.L.
AC-1 44
AC-2 55
OC-1 44
OC-2 34
LB-1 48
LB-2 53
LB-3 47
100% SATURATION CURVE (SP. G=2.70)
OC-2
LB-1 & LB-3
LB-2
OC-1
AC-2
DRY DENSITY P.C.F.
MOISTURE CONTENT - PERCENT OF DRY WEIGHT


LB-3
M-2
M-3
M-1
SHEAR STRESS T/S.F.
COMPACTED
REMOLDING MOISTURE CONTENT - VARIATION FROM OPT. MU







SYM DESCRIPTION DATE APP'D

REVISIONS

OSAGE RIVER BASIN

HILLSDALE LAKE

BIG BULL CREEK

2

TEST DATA SUMMARY
COMPACTED EMBANKMENT MATERIAL
"S" AND COMPACTION TESTS

In 80 sheets | Sheet No 1 | Scale as shown

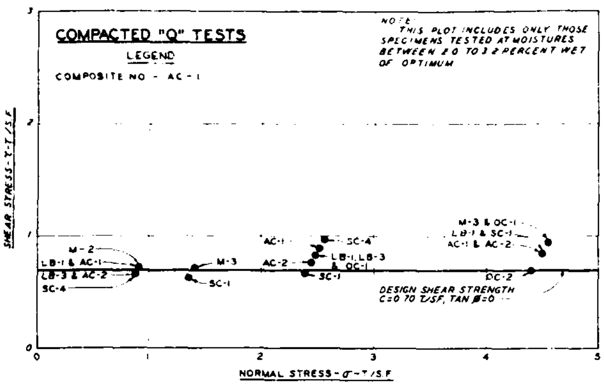
CORPS OF ENGINEERS
KANSAS CITY DISTRICT

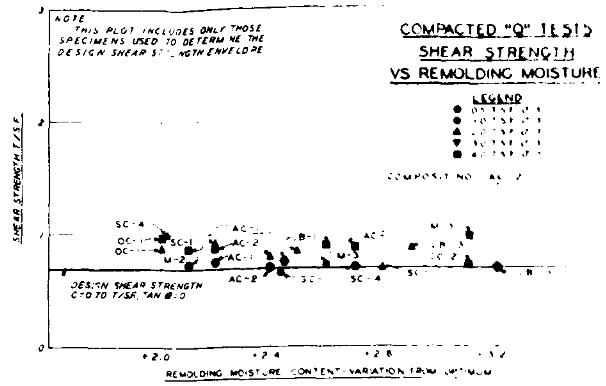
U S ARMY
MARCH 1971

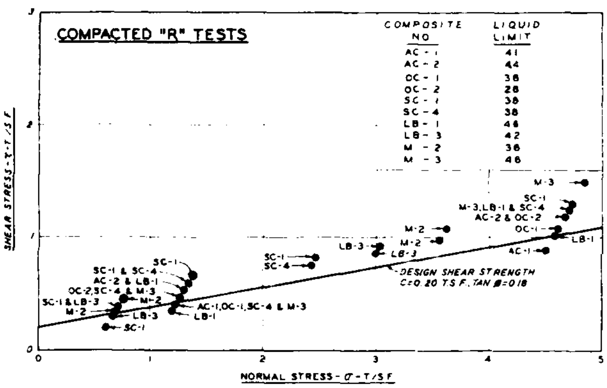
Submitted | Recommended | Approved

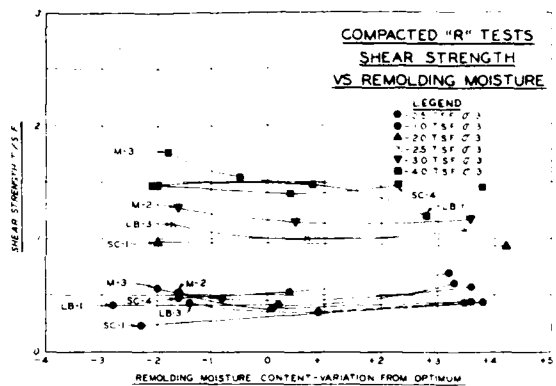
R K B | L E M - C P W | R F D | DM-7 | 0-15-185

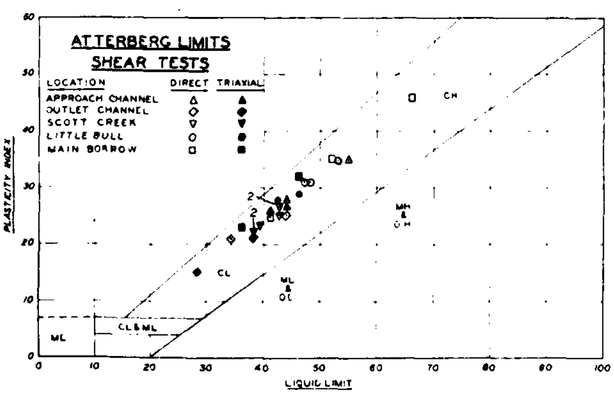
PLATE NO 46

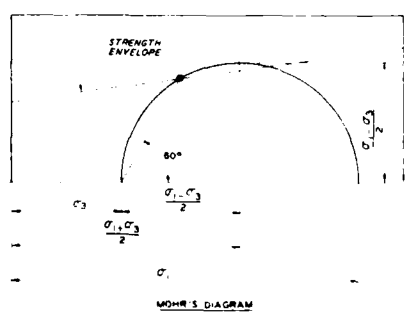

COMPACTED "Q" TESTS
LEGEND
COMPOSITE NO - AC - 1
NOTE
THIS PLOT INCLUDES ONLY THOSE SPECIMENS TESTED AT MOISTURES BETWEEN 2.0 TO 3.2 PERCENT WET OF OPTIMUM
DESIGN SHEAR STRENGTH
C=0.70 T/SF, TAN Ø=0
SHEAR STRESS - T - T/S.F.
NORMAL STRESS - σ - T/S.F.

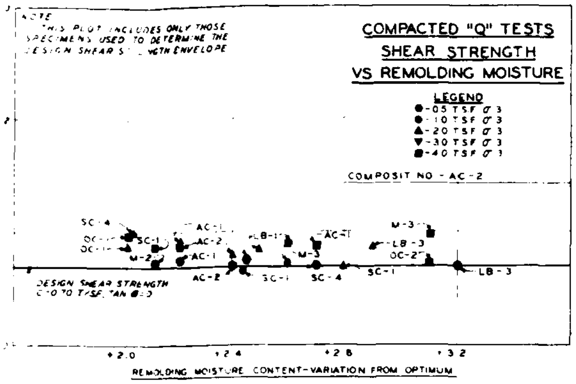

COMPACTED "Q" TESTS
SHEAR STRENGTH
VS REMOLDING MOISTURE
LEGEND
DESIGN SHEAR STRENGTH
SHEAR STRENGTH T/S.F.
REMOLDING MOISTURE CONTENT - VARIATION FROM OPTIMUM

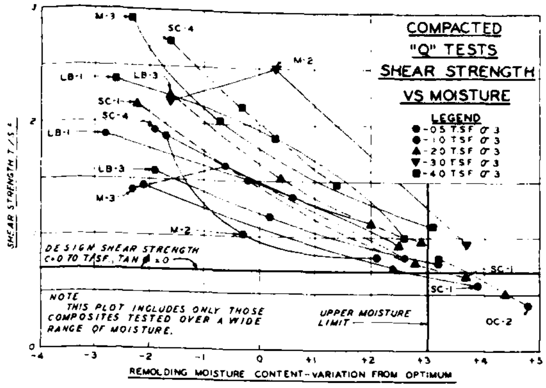

COMPACTED "R" TESTS
COMPOSITE NO
LIQUID LIMIT
AC - 1 41
AC - 2 44
OC - 1 38
OC - 2 28
SC - 1 38
SC - 4 38
LB - 1 46
LB - 3 42
M - 2 36
M - 3 46
DESIGN SHEAR STRENGTH
C=0.20 T.S.F., TAN Ø=0.18
SHEAR STRESS - T - T/S.F.
NORMAL STRESS - σ - T/S.F.

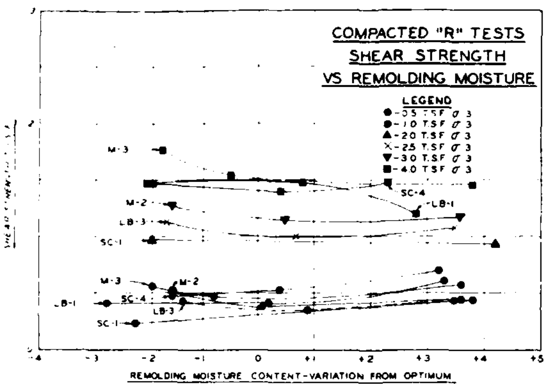

COMPACTED "R" TESTS
SHEAR STRENGTH
VS REMOLDING MOISTURE
LEGEND
SHEAR STRENGTH T/S.F.
REMOLDING MOISTURE CONTENT - VARIATION FROM OPTIMUM

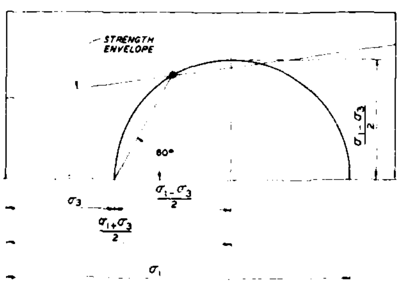

ATTERBERG LIMITS
SHEAR TESTS
LOCATION
DIRECT
TRIAXIAL
APPROACH CHANNEL
OUTLET CHANNEL
SCOTT CREEK
LITTLE BULL
MAIN BORROW
CH
CL
MH & OH
ML & OL
CL & ML
ML
PLASTICITY INDEX
LIQUID LIMIT


STRENGTH ENVELOPE
MOHR'S DIAGRAM









MOHR'S DIAGRAM

SYM	DESCRIPTION	DATE	APP'D.
	REVISIONS		

OSAGE RIVER BASIN

HILLSDALE LAKE

BIG BULL CREEK

2

TEST DATA SUMMARY
COMPACTED EMBANKMENT MATERIAL
"Q", "R" AND ATTERBERG LIMIT TESTS

In 60 sheets — Sheet No 2 — Scale as shown

CORPS OF ENGINEERS
KANSAS CITY DISTRICT

U.S. ARMY
MARCH 1971

Submitted — Recommended — Approved

COMPUTED BY R.K.B. — DRAWN BY P.S.T.-C.P.W. — CHECKED BY R.F.D.

DM-14 — FILE NO 0-15-186

PLATE NO 47

DATA ON COMPOSITE SAMPLES
COMPACTED EMBANKMENT MATERIAL

COMPOSITE NO	HOLE NO	SAMPLE DEPTH	CLASSIFICATION SYM	L L	P L	P I	DRY DENSITY MAX	AT TEST INITIAL	WATER CONTENT OPT	AT TEST INITIAL	PERCENT SATURATION	"Q" TEST TAN Ø	C TSF	"R" TEST TAN Ø	C TSF	"S" TEST TAN Ø	C TSF	LOCATION
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SC-2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SC-4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
LB-2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	104.0	99.3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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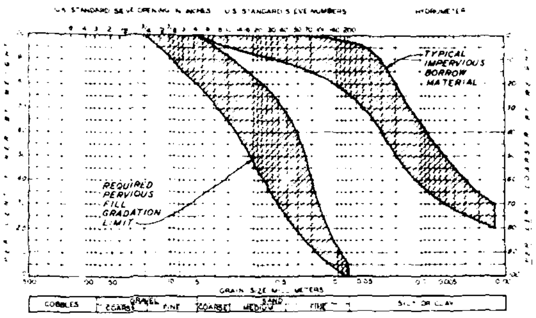
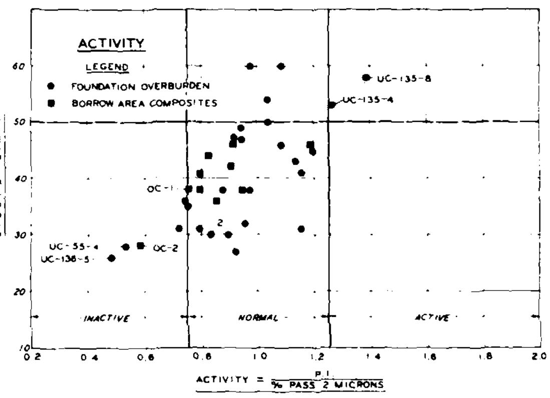
SAMPLES
T MATERIAL

NT	"Q" TEST		"R" TEST		"S" TEST		LOCATION
PERCENT SATURATION	TAN Ø	C T.S.F.	TAN Ø	C T.S.F.	TAN Ø	C T.S.F.	



GRADATIONS OF PERVIOUS AND IMPERVIOUS



ACTIVITY = $\frac{P.I.}{\%\ PASS\ 2\ MICRONS}$

SYM	DESCRIPTION	DATE	APP'D

REVISIONS

OSAGE RIVER BASIN

HILLSDALE LAKE

BIG BULL CREEK

TEST DATA SUMMARY
COMPACTED EMBANKMENT MATERIAL
ACTIVITY, GRADATIONS AND TABULATED DATA

In 60 sheets — Sheet No 3 — Scale as shown

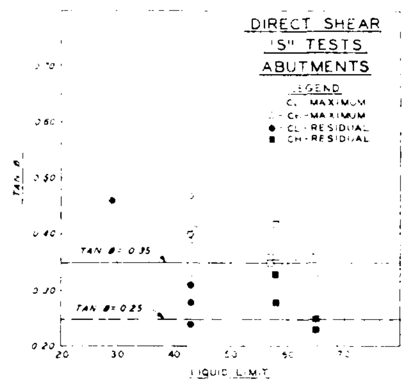
CORPS OF ENGINEERS
KANSAS CITY DISTRICT

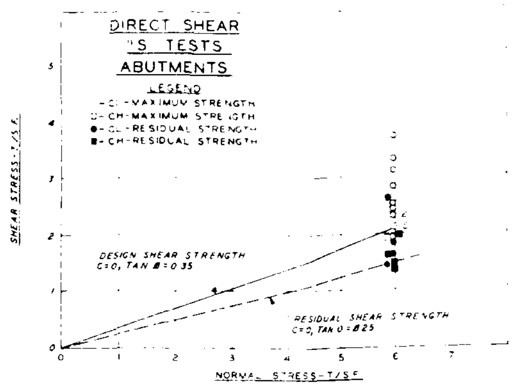
U.S. ARMY
MARCH 1971

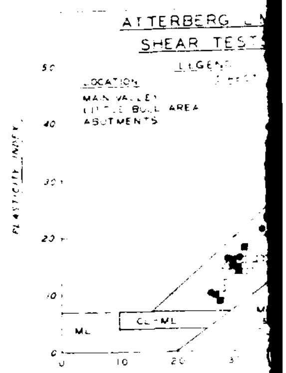
Submitted — Recommended — Approved

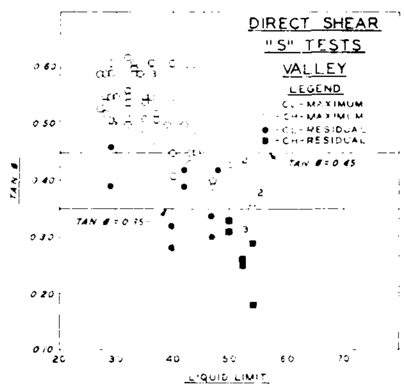
RKB PST JPW RFD DM-7 0-15-187

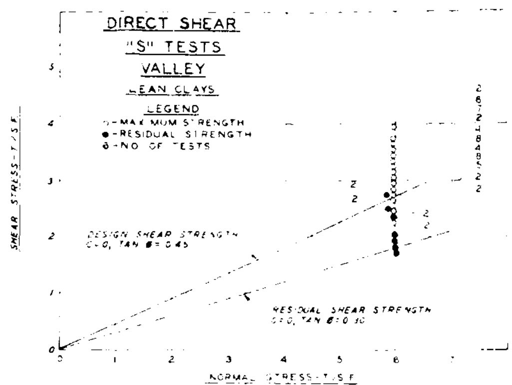
PLATE NO 48

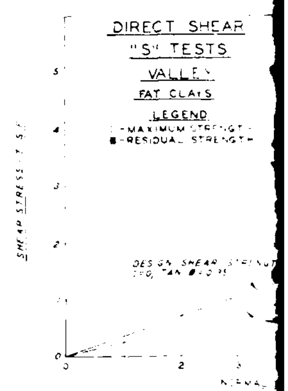

DIRECT SHEAR
"S" TESTS
ABUTMENTS
LEGEND
TAN Ø = 0.35
TAN Ø = 0.25
LIQUID LIMIT

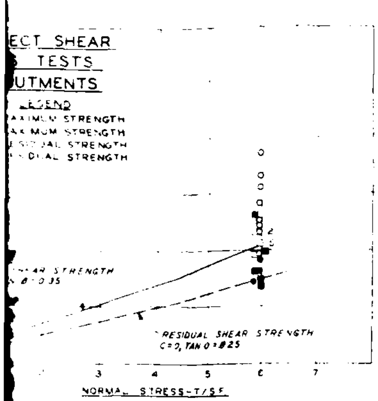

DIRECT SHEAR
"S" TESTS
ABUTMENTS
LEGEND
CL-MAXIMUM STRENGTH
CH-MAXIMUM STRENGTH
CL-RESIDUAL STRENGTH
CH-RESIDUAL STRENGTH
DESIGN SHEAR STRENGTH
C=0, TAN Ø = 0.35
RESIDUAL SHEAR STRENGTH
C=0, TAN Ø = 0.25
SHEAR STRESS-T/S.F.
NORMAL STRESS-T/S.F.

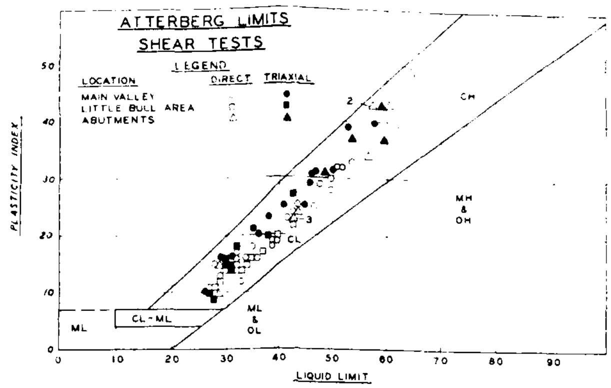

LOCATION
ABUTMENTS
CL-ML
ML

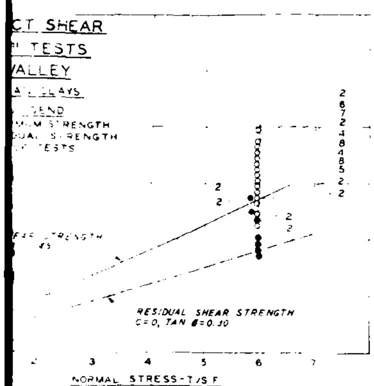

DIRECT SHEAR
"S" TESTS
VALLEY
LEGEND
CL-MAXIMUM
CH-MAXIMUM
CL-RESIDUAL
CH-RESIDUAL
TAN Ø = 0.45
TAN Ø = 0.35
LIQUID LIMIT

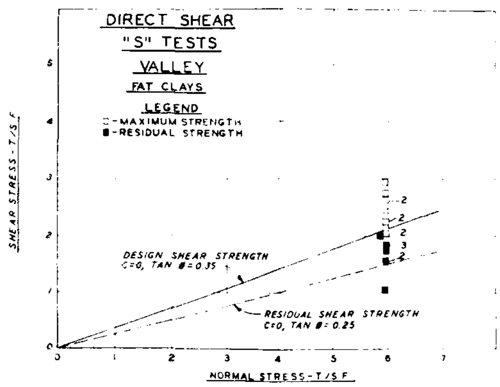

DIRECT SHEAR
"S" TESTS
VALLEY
LEAN CLAYS
LEGEND
RESIDUAL STRENGTH
DESIGN SHEAR STRENGTH
C=0, TAN Ø = 0.45
RESIDUAL SHEAR STRENGTH
SHEAR STRESS-T/S.F.


DIRECT SHEAR
"S" TESTS
FAT CLAYS
LEGEND









SYM DESCRIPTION DATE APPR

REVISIONS

OSAGE RIVER BASIN

HILLSDALE LAKE

BIG BULL CREEK

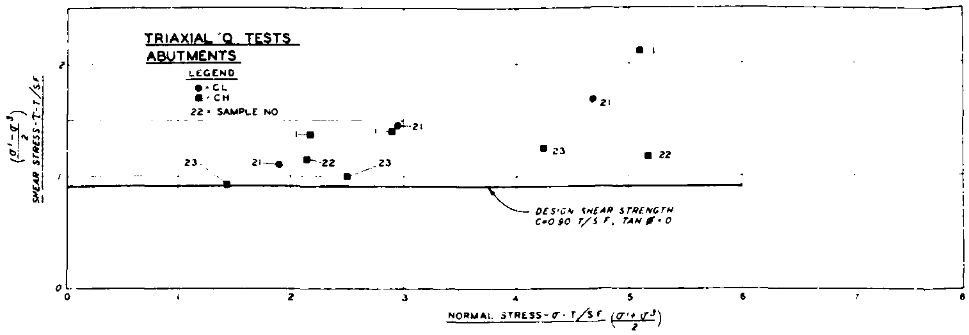
TEST DATA SUMMARY
FOUNDATION OVERBURDEN
"S" AND ATTERBERG LIMIT TESTS

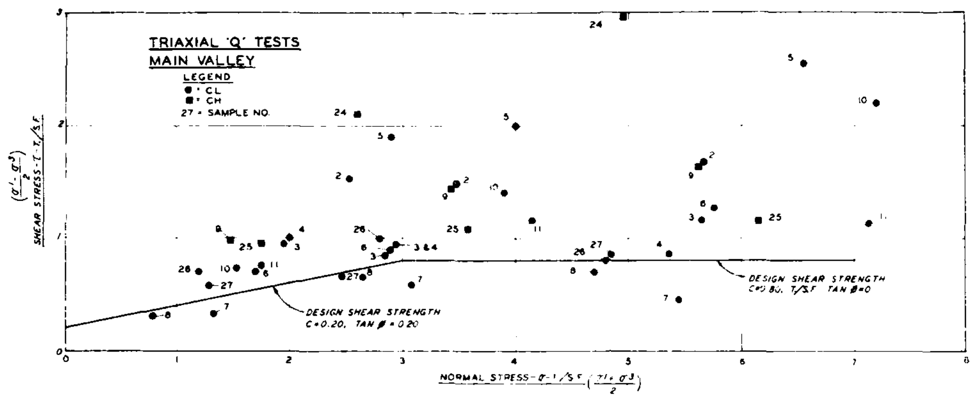
In 60 sheets — Sheet No. 4 — Scale as shown

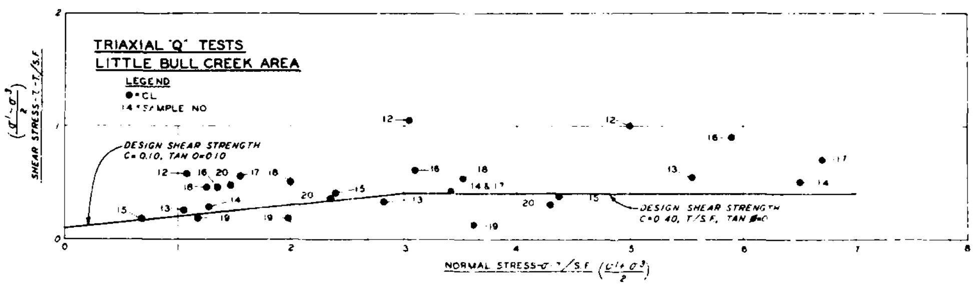
CORPS OF ENGINEERS, KANSAS CITY DISTRICT — U.S. ARMY, MARCH 1971

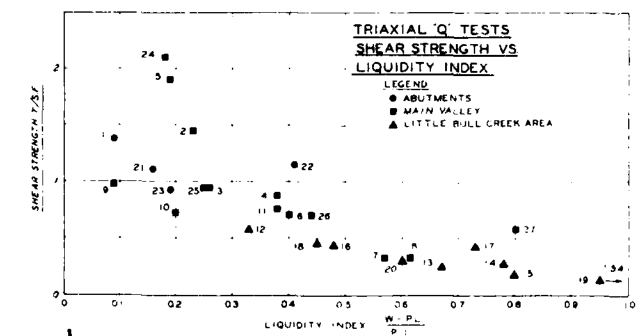
R.K.B. — J.A.M. — R.F.D. — DM-7 — O-15-188

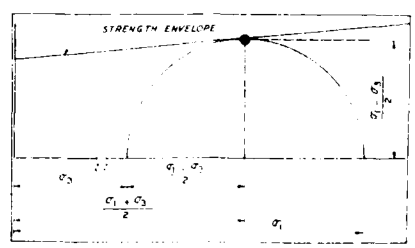
PLATE NO 49











MOHR'S DIAGRAM

"Q" TEST DATA
ABUTMENTS

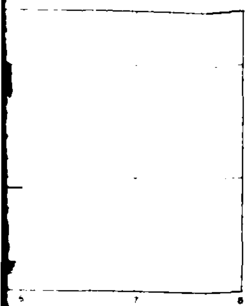
SYMBOL	HOLE NUMBER	SAMPLE DEPTH	CLASSIFICATION	RANGE

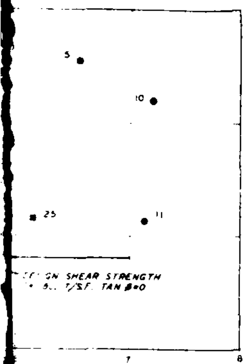
"Q" TEST DATA
MAIN VALLEY

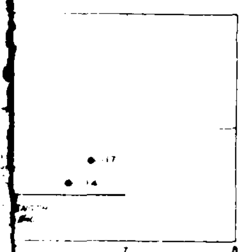
SYMBOL	HOLE NUMBER	SAMPLE DEPTH	CLASSIFICATION	RANGE OF

"Q" TEST DATA
LITTLE BULL CREEK AREA

SYMBOL	HOLE NUMBER	SAMPLE DEPTH	CLASSIFICATION	RANGE

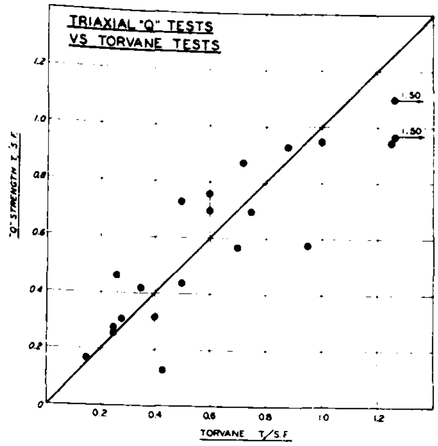






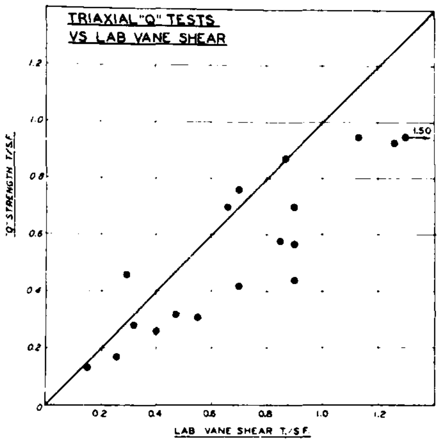
"Q" TEST DATA
ABUTMENTS

SYMBOL	HOLE NUMBER	SAMPLE DEPTH	CLASSIFICATION				RANGE OF INITIAL CONDITIONS		
			SYM	LL	PL	PI	DRY DENSITY	PERCENT MOISTURE	PERCENT SATURATION
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]



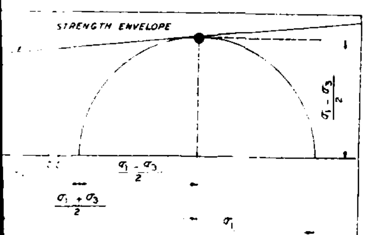
"Q" TEST DATA
MAIN VALLEY

SYMBOL	HOLE NUMBER	SAMPLE DEPTH	CLASSIFICATION				RANGE OF INITIAL CONDITIONS		
			SYM	LL	PL	PI	DRY DENSITY	PERCENT MOISTURE	PERCENT SATURATION
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]



"Q" TEST DATA
LITTLE BULL CREEK AREA

SYMBOL	HOLE NUMBER	SAMPLE DEPTH	CLASSIFICATION				RANGE OF INITIAL CONDITIONS		
			SYM	LL	PL	PI	DRY DENSITY	PERCENT MOISTURE	PERCENT SATURATION
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]



MOHR'S DIAGRAM

SYM	DESCRIPTION	DATE	APP'D

REVISIONS

OSAGE RIVER BASIN

HILLSDALE LAKE

BIG BULL CREEK

TEST DATA SUMMARY
FOUNDATION OVERBURDEN
"Q" TESTS

2

In 60 sheets — Sheet No 5 — Scale as shown

CORPS OF ENGINEERS
KANSAS CITY DISTRICT

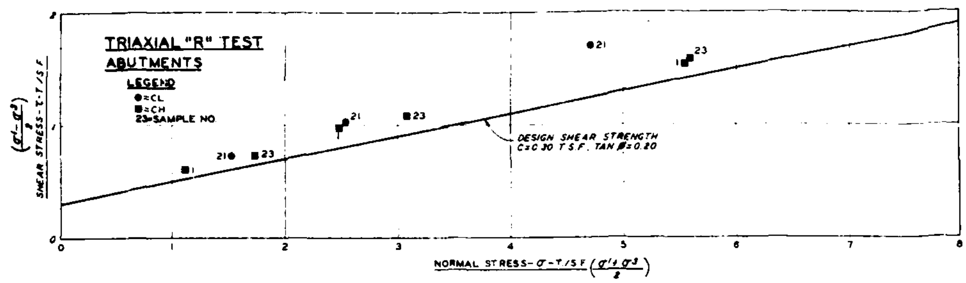
U. S. ARMY
MARCH 1971

Submitted — Recommended — Approved

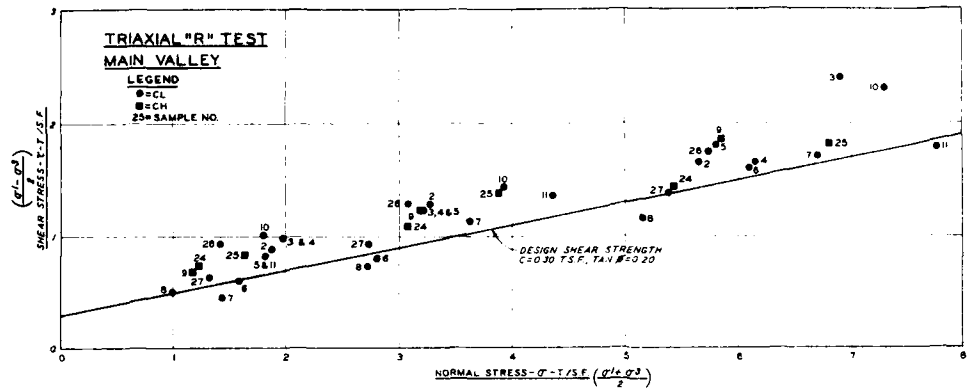
COMPILED BY RKB — DRAWN BY PST — CHECKED BY RFD

DM-7 — 0-15-189

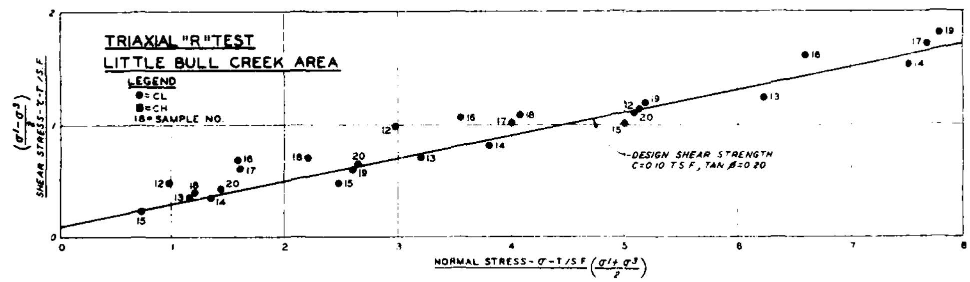
PLATE NO 50



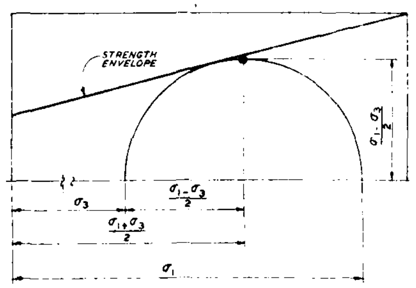
SYMBOL	HOLE NUMBER	SAMPLE DEPTH
[illegible]	[illegible]	[illegible]
21	UC-58	[illegible]
22	UC-59	[illegible]
23	[illegible]	[illegible]



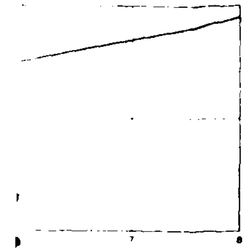
SYMBOL	HOLE NUMBER	SAMPLE DEPTH
[illegible]	[illegible]	[illegible]

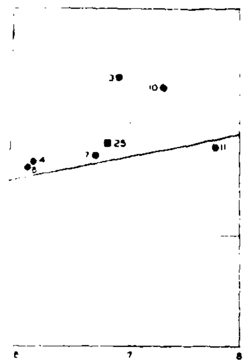


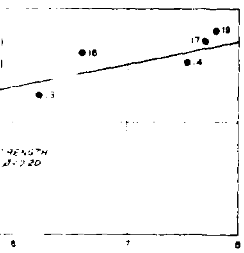
SYMBOL	HOLE NUMBER	SAMPLE DEPTH
[illegible]	[illegible]	[illegible]



MOHR'S DIAGRAM







"R" TEST DATA
ABUTMENTS

SYMBOL	HOLE NUMBER	SAMPLE DEPTH	CLASSIFICATION SYM.	L.L.	P.L.	P.I.	RANGE OF INITIAL CONDITIONS DRY DENSITY	PERCENT MOISTURE	PERCENT SATURATION
1	UC-49	7.5-9.3	CH	60	17	43	98.1-100.8	22.7-23.0	89-93
21	UC-58	4.0-5.9	CL	49	18	31	98.1-99.5	23.9-24.5	96-98
22	UC-59	8.7-9.3	CH	60	23	37	—	—	—
23	UC-61	4.0-5.9	CH	54	17	37	99.2-99.3	25.4-25.6	99-100

"R" TEST DATA
MAIN VALLEY

SYMBOL	HOLE NUMBER	SAMPLE DEPTH	CLASSIFICATION SYM	L.L.	P.L.	P.I.	RANGE OF INITIAL CONDITIONS DRY DENSITY	PERCENT MOISTURE	PERCENT SATURATION
2	UC-51	7.0-8.9	[illegible]	47	16	31	99.9-101.9	22.3-22.8	89-93
3	UC-51	15.0-16.9	CL	41	16	25	100.2-100.[illegible]	24.0-24.2	96-97
4	UC-51	19.0-20.9	CL	35	14	21	104.6-106.3	21.1-21.6	95-97
5	UC-52	9.0-10.9	CL	47	16	31	100.0-101.2	21.9-22.7	91
6	UC-52	17.0-18.9	CL	36	16	20	96.0-98.3	23.7-25.4	91-93
7	UC-52	21.0-22.9	CL	38	15	23	92.7-96.4	27.2-28.5	96-100
8	UC-53	10.0-11.9	CL	31	16	15	94.2-95.3	26.4-26.6	93-95
9	UC-54	7.0-8.9	CH	50	19	31	97.1-97.4	24.3-24.6	92-94
10	UC-54	13.0-14.9	CL	45	20	25	95.6-97.9	25.4-25.9	92-95
11	UC-54	21.0-22.9	CL	46	17	29	93.0-93.7	27.4-27.8	93-96
24	UC-135	6.3-8.4	CH	53	14	39	98.8-102.3	20.2-21.7	85-88
25	UC-135	14.5-16.4	CH	58	18	40	93.9-95.7	28.1-28.5	99
26	UC-136	5.7-7.9	CL	30	14	16	104.2-105.6	21.4-21.9	93-96
27	UC-136	10.0-11.9	CL	26	16	10	101.2-101.5	23.1-23.9	98-100

"R" TEST DATA
LITTLE BULL CREEK AREA

SYMBOL	HOLE NUMBER	SAMPLE DEPTH	CLASSIFICATION SYM	L.L.	P.L.	P.I.	RANGE OF INITIAL CONDITIONS DRY DENSITY	PERCENT MOISTURE	PERCENT SATURATION
12	UC-55	7.0-8.9	CL	28	19	9	97.0-100.5	21.9-23.3	89-90
13	UC-55	13.0-14.9	CL	30	15	15	94.7-95.5	25.5-25.8	89
14	UC-55	21.0-22.9	CL	[illegible]	14	18	91.5-92.6	28.0-28.3	93-95
15	UC-56	9.0-10.9	CL	31	16	15	90.2-90.4	27.[illegible]-27.6	86-87
16	UC-56	17.0-18.9	CL	43	16	27	92.8-93.1	27.[illegible]-28.3	89-91
17	UC-56	21.0-22.9	CL	30	15	15	93.2-95.5	26.8-28.4	96
18	UC-57	[illegible]	CL	38	18	20	91.4-92.3	28.2-28.8	94-96
19	UC-57	12.0-13.9	CL	27	16	11	87.4-93.[illegible]	31.3-34.1	100+
20	UC-57	15.0-15.9	CL	31	16	15	93.2-94.3	29.0-30.9	100+

SYM	DESCRIPTION	DATE	APP'D.

REVISIONS

OSAGE RIVER BASIN

HILLSDALE LAKE

BIG BULL CREEK

TEST DATA SUMMARY
FOUNDATION OVERBURDEN
"R" TESTS

In 60 sheets — Sheet No. 6 — Scale: as shown

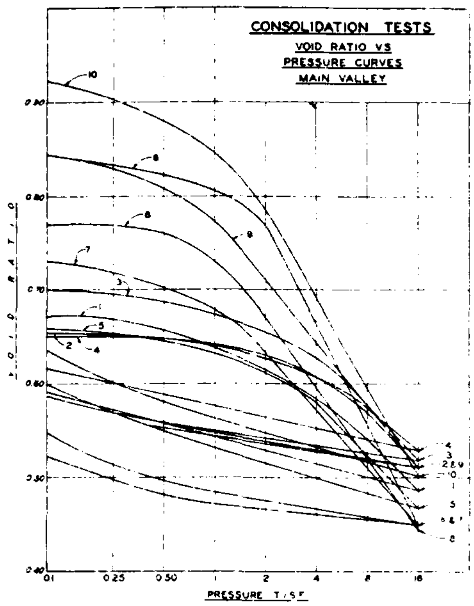
CORPS OF ENGINEERS, KANSAS CITY DISTRICT — U. S. ARMY — MARCH 1971

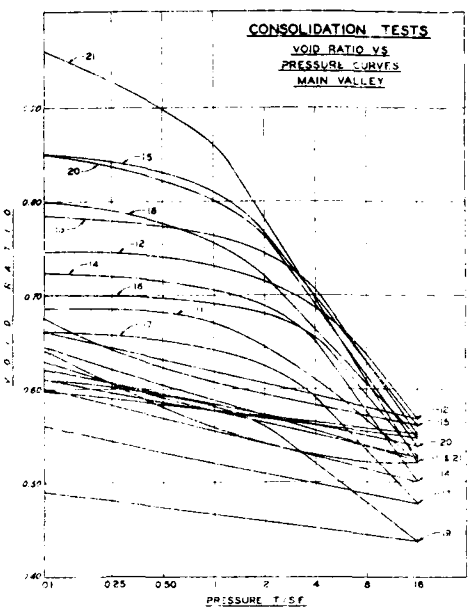
Submitted: CHIEF, DAMS & FOUNDATIONS SECT. — Recommended: CHIEF, FOUNDATIONS & MATLS BR. — Approved: CHIEF, ENGINEERING DIVISION

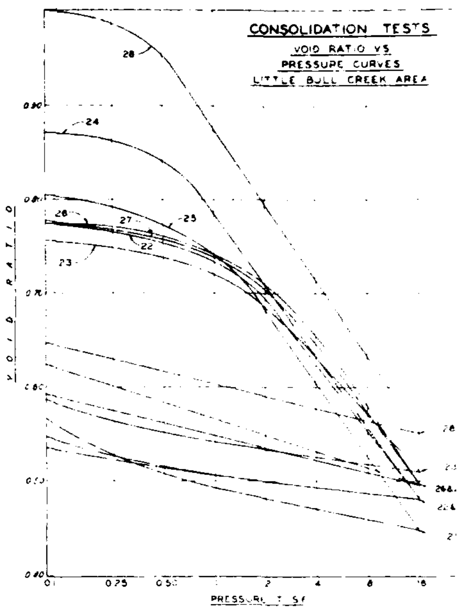
COMPILED BY R.K.B. — DRAWN BY C.P.W. — CHECKED BY R.F.A.

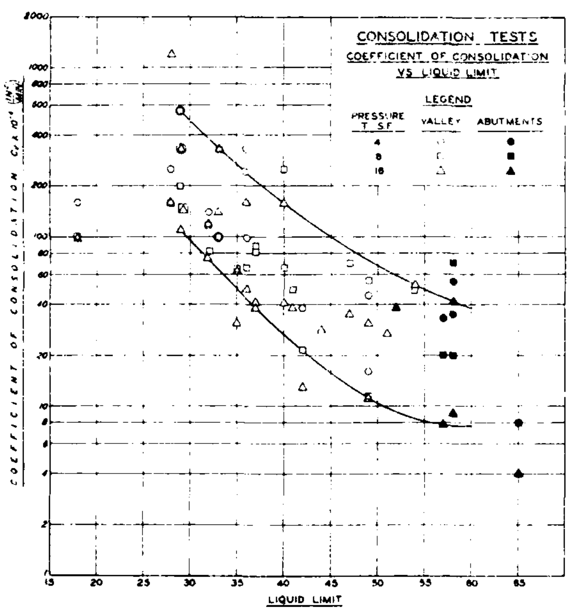
DM-7 — FILE NO. 0-15-190

PLATE NO 51







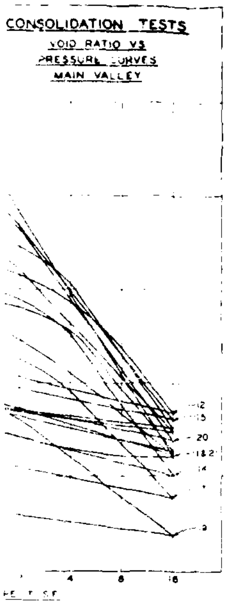


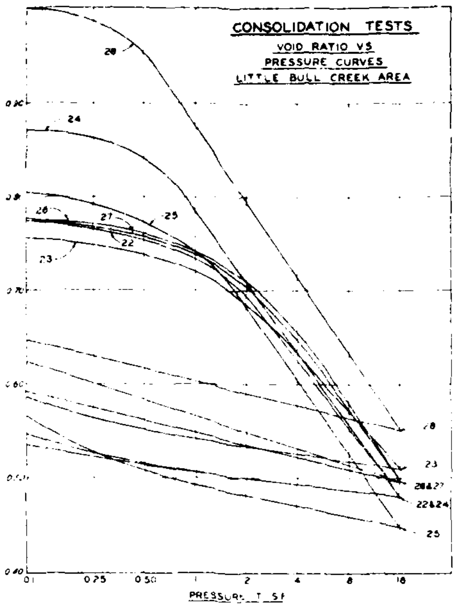
CONSOLIDATION TEST DATA
MAIN VALLEY

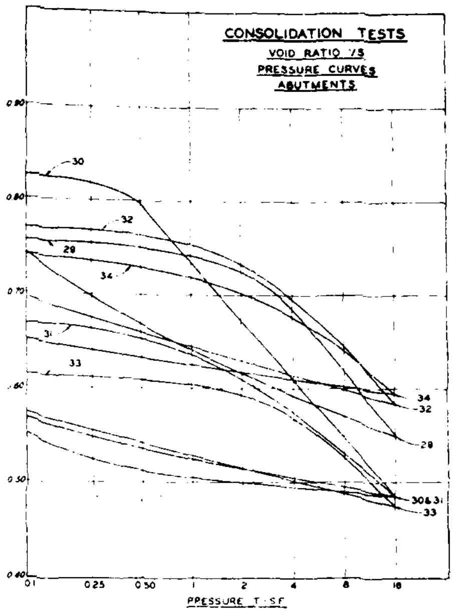
SYMBOL	HOLE NUMBER	SAMPLE DEPTH	L.L.	Po TSF	Pc TSF	E	E4	Cc	C	Cv IN²/MIN 4 TSF	8 TSF	16 TSF
1	[illegible]	[illegible]	[illegible]	[illegible]	2.8	[illegible]	[illegible]	0.04	[illegible]	[illegible]	[illegible]	[illegible]
2	[illegible]	[illegible]	[illegible]	[illegible]	4.0	0.653	[illegible]	[illegible]	[illegible]		0089	[illegible]
3	[illegible]	[illegible]	35	1.10	[illegible]	0.700	52	0.04			0.0042	[illegible]
4	[illegible]	[illegible]	[illegible]	[illegible]	4.0	0.651	0.53	[illegible]	[illegible]			[illegible]
5	[illegible]	[illegible]	44	0.70	4.0	0.656	0.46	0.05	[illegible]			0.0038
6	[illegible]	[illegible] 24.9	44	1.40	8.0	0.845	0.45	0.34	[illegible]			
7	[illegible]	[illegible]	[illegible]	[illegible]	5.0	0.730	0.45	[illegible]	[illegible]		0.0140	[illegible]
8	[illegible]	12.5-13.0	29	[illegible]	0.9	0.770	0.44	0.05		[illegible]	0.0200	[illegible]
9	[illegible]	[illegible]	[illegible]	0.90	0.9	0.845	0.52		[illegible]	[illegible]	0.0160	[illegible]
10	[illegible]	20.8-[illegible]	[illegible]	1.20	3.0	0.923	0.50		[illegible]		[illegible]	[illegible]
11	UC-54	[illegible]	44	[illegible]	[illegible]	0.686	[illegible]	0.04	[illegible]	[illegible]	0.0011	[illegible]
12	UC-54	12.3-[illegible]	47	0.75	4.0	0.745	0.51	0.04	[illegible]		0.0070	[illegible]
13	UC-54	[illegible]	[illegible]	1.00	3.0	0.715	[illegible]	0.04	[illegible]		0.0066	[illegible]
14	UC-54	19.0-19.5	[illegible]	1.10	3.0	0.724	0.50	0.04	[illegible]		0.0049	[illegible]
15	UC-135	4.3-6.[illegible]	54	0.30	[illegible]	0.847	0.55	0.05	[illegible]		0.0049	[illegible]
16	UC-135	13.3-13.[illegible]	[illegible]	0.80	[illegible]	[illegible]	0.52	0.05	[illegible]	0.0038	0.0022	[illegible]
17	UC-135	17.3-19.4	[illegible]	[illegible]	3.0	[illegible]	0.46	0.05	[illegible]	[illegible]	[illegible]	[illegible]
18	UC-136	3.2-5.6	[illegible]	0.25	4.0	0.799	0.55	[illegible]	[illegible]	0.0330	0.0250	[illegible]
19	UC-136	6.[illegible]-9.9	[illegible]	0.55	3.0	0.621	0.43	0.07	[illegible]		0.0120	[illegible]
20	UC-136	[illegible]-15.4	[illegible]	0.90	[illegible]	0.849	0.54	0.04	0.30	[illegible]	0.0066	[illegible]
21	UC-136	19.0-20.9	31	1.10	2.0	0.958	0.52		0.38	0.0099	0.0099	[illegible]

CONSOLIDATION TEST DATA
LITTLE BULL CREEK AREA

SYMBOL	HOLE NUMBER	SAMPLE DEPTH	L.L.	Po TSF	Pc TSF	E	E4	C	C
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]







CONSOLIDATION TEST DATA
MAIN VALLEY

P₀ T.S.F.	Pc T.S.F.	E	Ea	Ca	Cc	Cv (IN²/MIN) 4 T.S.F.	Cv 8 T.S.F.	Cv 16 T.S.F.
[illegible]	[illegible]	[illegible]	[illegible]	0.04	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		0.0089	[illegible]
[illegible]	[illegible]	0.700	0.57	0.03	[illegible]		[illegible]	[illegible]
[illegible]	[illegible]	0.551	0.43	[illegible]	[illegible]			[illegible]
[illegible]	[illegible]	0.558	[illegible]	0.05	[illegible]			[illegible]
[illegible]	[illegible]	0.845	[illegible]	0.04	0.41			
[illegible]	[illegible]	0.770	[illegible]	0.03	0.19		0.0140	[illegible]
[illegible]	[illegible]	0.770	0.44	0.05	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	0.845	0.57		0.23	[illegible]	0.0150	[illegible]
[illegible]	[illegible]	0.929	0.50		[illegible]		0.0250	[illegible]
[illegible]	[illegible]	0.696	[illegible]	0.04	0.14	[illegible]	0.0011	0.0051
[illegible]	[illegible]	0.749	0.57	0.04	0.25		0.0070	0.0035
[illegible]	[illegible]	0.785	0.55	0.04	0.30		0.0066	0.0041
[illegible]	[illegible]	0.724	0.50	0.04	0.28		0.0049	0.0038
[illegible]	2.0	0.847	0.56	0.05	0.24		0.0042	0.0052
[illegible]	[illegible]	[illegible]	0.57	0.05	0.24	0.0018	0.0022	0.0013
[illegible]	[illegible]	[illegible]	0.49	0.03	0.20	0.0140	0.0082	[illegible]
[illegible]	[illegible]	0.799	0.55	0.03	0.23	0.0330	0.0250	0.0160
[illegible]	[illegible]	0.621	0.43	0.03	0.21		0.0120	0.0170
[illegible]	[illegible]	0.849	0.54	0.04	0.30	0.0099	0.0066	0.0049
[illegible]	2.0	0.958	0.52		0.38	0.0099	0.0099	0.0140

CONSOLIDATION TEST DATA
LITTLE BULL CREEK AREA

SYMBOL	HOLE NUMBER	SAMPLE DEPTH	L.L.	P₀ T.S.F.	Pc T.S.F.	E	Ea	Ca	Cc	Cv (IN²/MIN) 4 T.S.F.	Cv 8 T.S.F.	Cv 16 T.S.F.
[illegible]	[illegible]	[illegible]	28	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.0099	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.60	0.40	[illegible]	0.26	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.45	0.04	0.31		[illegible]	[illegible]
[illegible]	[illegible]	[illegible]-19.8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.786	0.49	[illegible]	[illegible]			
28	[illegible]	[illegible]	35	0.30	0.4	[illegible]	[illegible]		0.29			[illegible]

CONSOLIDATION TEST DATA
ABUTMENTS

SYMBOL	HOLE NUMBER	SAMPLE DEPTH	L.L.	P₀ T.S.F.	Pc T.S.F.	E	Ea	Ca	Cc	Cv (IN²/MIN) 4 T.S.F.	Cv 8 T.S.F.	Cv 16 T.S.F.
9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.04	0.24		[illegible]	0.0004
[illegible]	[illegible]	[illegible]	29			0.825	0.49		0.23			
[illegible]	[illegible]	[illegible]	58	[illegible]	1.8	[illegible]	0.49	[illegible]	[illegible]	[illegible]	0.0070	[illegible]
[illegible]	[illegible]	[illegible]	58	[illegible]	[illegible]	[illegible]	0.58	[illegible]	[illegible]	[illegible]	0.0020	0.0009
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		0.18			0.0018
34	[illegible]	[illegible]	[illegible]	0.30	[illegible]	[illegible]	[illegible]	[illegible]	0.14	[illegible]	[illegible]	[illegible]

SYM.	DESCRIPTION	DATE	APP'D.

REVISIONS

OSAGE RIVER BASIN

HILLSDALE LAKE

BIG BULL CREEK

TEST DATA SUMMARY
FOUNDATION OVERBURDEN
CONSOLIDATION TESTS

In 60 sheets — Sheet No. 7 — Scale: as shown

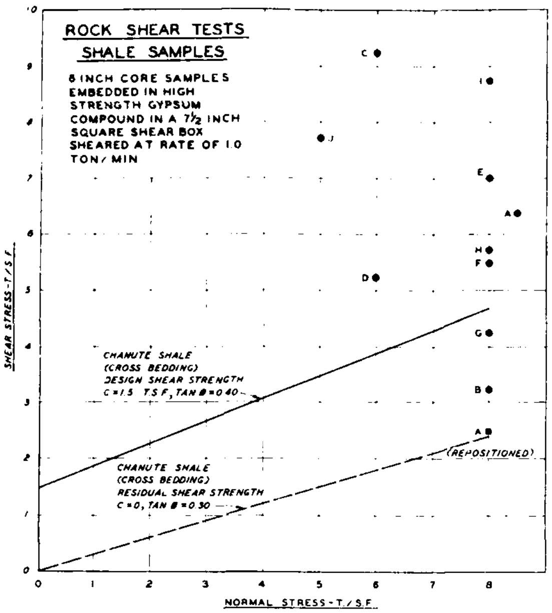
CORPS OF ENGINEERS
KANSAS CITY DISTRICT

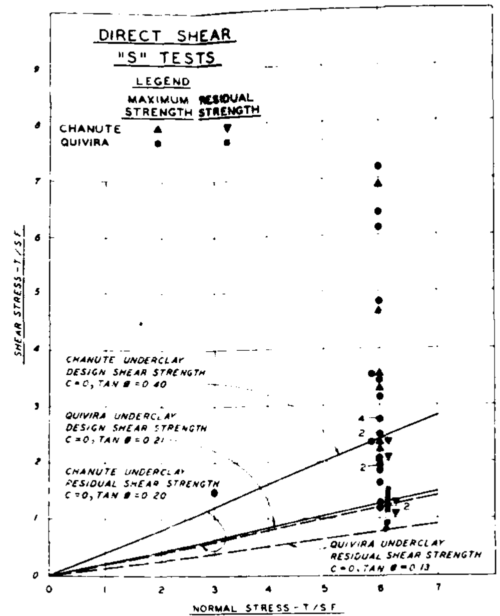
U. S. ARMY
MARCH 1971

Submitted: CHIEF, DAMS & FOUNDATIONS SECT. — Recommended: CHIEF, FOUNDATIONS & MAT'LS BR. — Approved: CHIEF, ENGINEERING DIVISION

COMPILED BY R. K. B. — DRAWN BY L. R. M. — CHECKED BY R. F. D. — DM-? — FILE NO. 0-15-191

PLATE NO 52





ROCK SHEAR TEST DATA

OUTLET WORKS - SHALES

SYMBOL	SAMPLE NO	SAMPLE DEPTH	DRY DENSITY	MOISTURE	HORIZONTAL DEFORMATION AT FAILURE	GEOLOGIC MEMBER
A*	UC-50-3	19.2-20.5	93.5	17.5	0.017	Chanute Underclay
B	UC-59-1	23.3-24.8	131.0	10.5	0.014	Chanute
C	UC-59-2	26.7-28.1	132.5	13.0	0.034	Chanute
D	UC-59-2	26.7-28.1	134.0	8.0	0.030	Chanute
E	UC-59-5	41.6-43.1	119.5	14.5	0.016	Chanute Underclay
F	UC-59-6	43.1-44.8	122.5	13.0	0.027	Chanute
G	UC-59-7	47.5-49.2	139.0	8.0	0.009	Chanute
H	UC-59-9	62.3-63.8	138.0	8.5	0.015	Quivira
I	UC-92-2	37.8-39.0	127.0	14.5	0.050	Chanute
J	UC-92-3	41.0-42.4	132.0	17.0	0.052	Chanute

* Note: Hole No UC-50 located on right abutment of dam

DIRECT SHEAR "S" TESTS

HOLE NO	SAMPLE DEPTH	INITIAL CONDITIONS DRY DENSITY	MOISTURE CONTENT	SATURATION	GEOLOGIC MEMBER
U-51	29.0-30.2	[illegible]	20.0	74	Quivira
[illegible]-59	[illegible]-53.1	138.0	8.0	100	Chanute
[illegible]	38.0-38.6	[illegible]	7.5	63	Chanute
[illegible]	45.3-45.8	128.0	10.5	[illegible]	Chanute
C-14[illegible]	29.0-26.3	[illegible]	14.0	85	Quivira
C-14[illegible]	[illegible]	[illegible]	[illegible]	100	Quivira
C-14[illegible]	[illegible]	[illegible]	9.5	82	Quivira
C-14[illegible]	[illegible]-30.3	[illegible]	9.5	78	Quivira
C-14[illegible]	31.3-32.0	[illegible]	12.0	97	Quivira
C-14[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Quivira
C-14[illegible]	34.9-[illegible]	[illegible]	9.0	75	Quivira
C-14[illegible]	34.9-35.3		8.0		Quivira
C-14[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Quivira
C-142	31.7-3[illegible]	[illegible]	16.5	89	Quivira
C-142	34.0-34.3	[illegible]	15.0	99	Quivira
C-142	34.9-35.3	125.0	[illegible]	99	Quivira
C-143	30.0-3[illegible]	[illegible]	[illegible]		Quivira
C-143					
C-143	33.[illegible]	[illegible]	15.5	94	Quivira
C-143			—		
C-144	57.3-57.4	[illegible]	11.5	100	Quivira
C-144	57.4-57.5	[illegible]	[illegible]	100	Quivira
C-144	59.5-60.3	134.0	10.0	95	Quivira

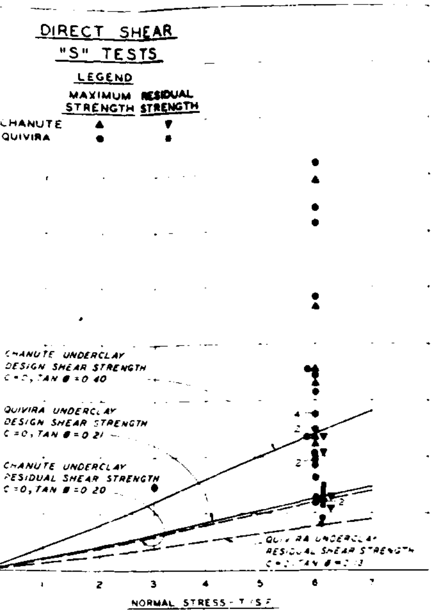
B[illegible]

BEDROCK UNIT NAME	RO[illegible] TYP[illegible]
Lane Shale	
Raytown Limestone	
Raytown Limestone	
Chanute Shale	[illegible]
Chanute Shale	
Chanute Shale	Sh[illegible]
Quivira Shale	
Quivira Shale	Sh[illegible]
Wea Shale	[illegible]
Fontana Shale	Sh[illegible]

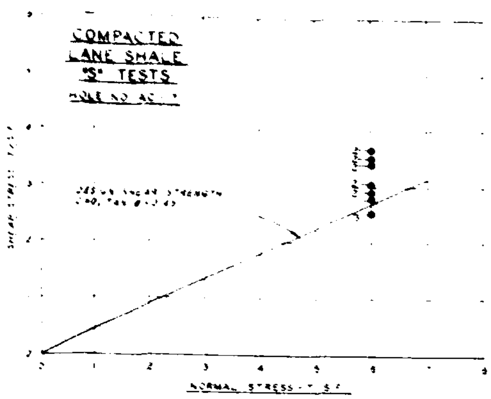
* Test procedure [illegible]

( ) Indicate [illegible]

DIRECT SHEAR "S" TESTS



COMPACTED LANE SHALE "S" TESTS



REMOLDED LANE SHALE

HOLE NO. AC-[illegible]

SAMPLE DEPTH	CLASSIFICATION SYM	L.L.	P.L.	P.I.	INITIAL CONDITIONS DRY DENS	MOIST	SAT
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
42.8-43.4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
45.4-46[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
67.5-68.3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

DIRECT SHEAR "S" TESTS

HOLE NO	SAMPLE DEPTH	INITIAL CONDITIONS DRY DENSITY	MOISTURE CONTENT	SATURATION	GEOLOGIC MEMBER
[illegible]	[illegible]-300	[illegible]	20.0	74	[illegible]
[illegible]	[illegible]-53	138[illegible]	8.0	[illegible]	Chanute
	35[illegible]-36[illegible]	129.0	7.5	63	Chanute
[illegible]	45[illegible]-458	128.0	10.5	93	Chanute
4[illegible]	2[illegible]-26.3	117.0	14.0	85	Quivira
4	[illegible]-25.8	130.0	11.0	00	Quivira
4	[illegible]-[illegible]8	130.0	9.5	92	Quivira
[illegible]	[illegible]-[illegible]3	128.0	9.5	[illegible]	Quivira
[illegible]	[illegible]3-32.0	130.0	12.[illegible]	9[illegible]	Quivira
[illegible]	[illegible]	131.0	[illegible]	9[illegible]	Quivira
[illegible]	34[illegible]-35[illegible]	127.5	9.0	7[illegible]	Quivira
[illegible]	34.9-35.3	—	8.0	—	Quivira
4	[illegible]	130.0	2[illegible]	[illegible]	Quivira
42	3[illegible]-3[illegible]	[illegible]	16.5	89	Quivira
4[illegible]	34[illegible]-34.3	120.0	15.0	99	Quivira
4[illegible]	34.3-35.3	125.0	13.5	99	Quivira
4[illegible]	[illegible]-3[illegible]	[illegible]	[illegible]		Quivira
4[illegible]	43[illegible]-33[illegible]	[illegible]	15.5	94	Quivira
4[illegible]			—		
44	57.3-57.4	[illegible]	11.5	[illegible]	Quivira
44	57.4-[illegible]	3[illegible]	[illegible]	[illegible]	Quivira
44	[illegible]-[illegible]	134.0	10.0	95	Quivira

BEDROCK TEST DATA - U.C. WET DRY TESTS

BEDROCK UNIT NAME	ROCK TYPE	UNCONFINED COMPRESSION TONS/FT² NO TESTS	AVG	MAX	MIN	DRY WEIGHT LBS/FT³ NO TESTS	AVG	MOISTURE CONTENT % DRY WEIGHT NO TESTS	AVG	WETTING & DRYING NO TESTS	AVERAGE % LOSS	CYCLE
Lane Shale	Sh	[illegible]	43.0	88.[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Raytown Limestone	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Paola Limestone	[illegible]	4	2[illegible]	4[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Chanute Shale	Ss&Sh	9	79.8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Chanute Shale	Sh	22	49.9	[illegible]	[illegible]	22	45[illegible]	22	[illegible]	[illegible]	[illegible]	[illegible]
Chanute Shale	Sh Underclay	5	2.2	2[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Quivira Shale	Sh	4	45.8	95.[illegible]	43.[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Quivira Shale	Sh Underclay	5	[illegible]	28.[illegible]	[illegible]	4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Wea Shale	Sh	[illegible]	42.[illegible]	[illegible]	[illegible]	[illegible]	4.4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Fontana Shale	Sh	2	25.5	35.[illegible]	34.[illegible]	[illegible]	4.7[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

*Test procedure used is a modification of the USGS [illegible] method. [illegible] cooled to room temperature, then immersed in 70°F water [illegible] minutes [illegible] drying oven. The cycle was repeated until specimen failed [illegible]

( ) indicate only one test not an average

SYM | DESCRIPTION | DATE | APPR.

REVISIONS

OSAGE RIVER BASIN

HILLSDALE LAKE

BIG BULL CREEK

TEST DATA SUMMARY
FOUNDATION SHALES

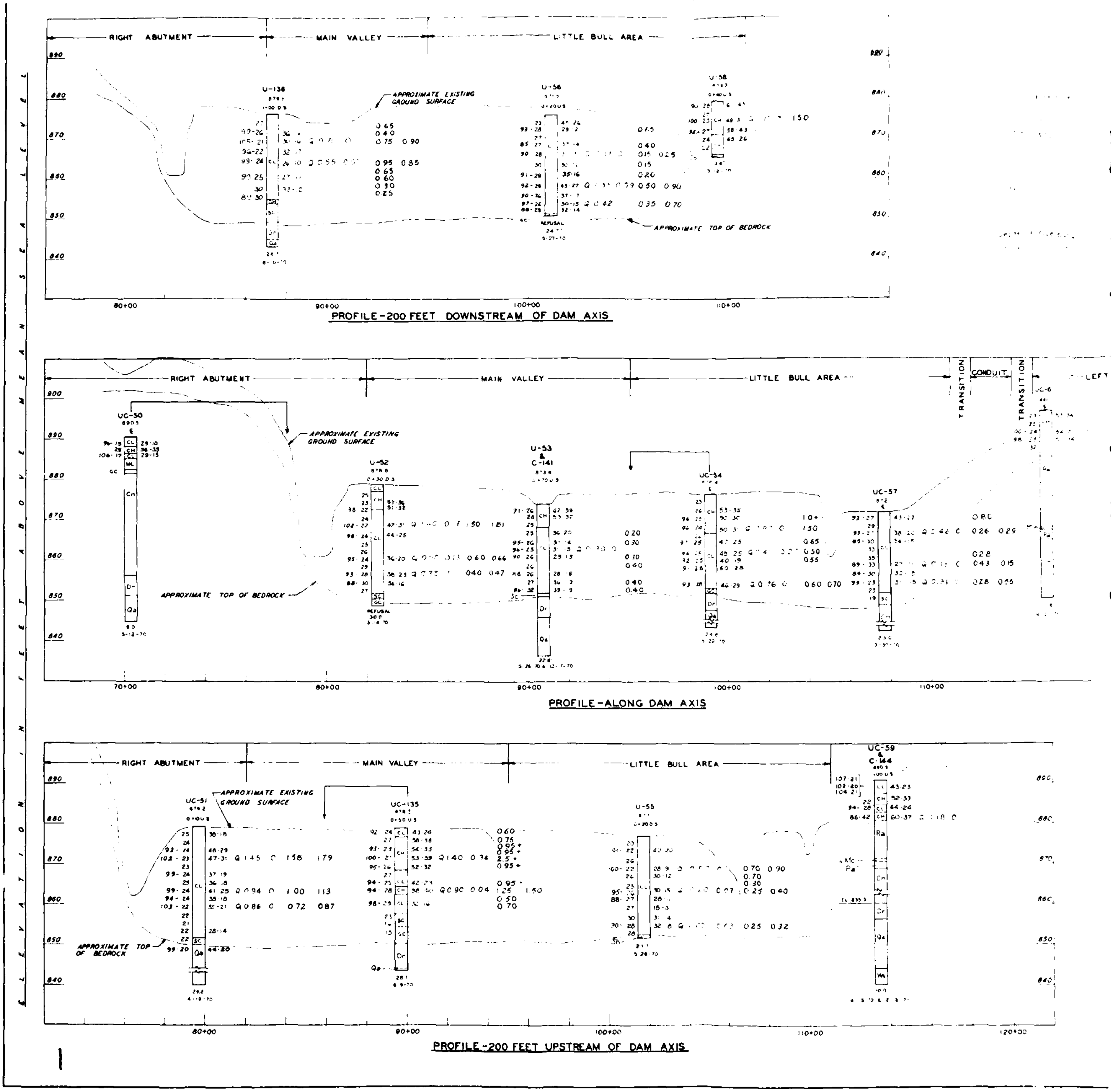
In 60 sheets | Sheet No. 3 | Scale as shown

CORPS OF ENGINEERS
KANSAS CITY DISTRICT

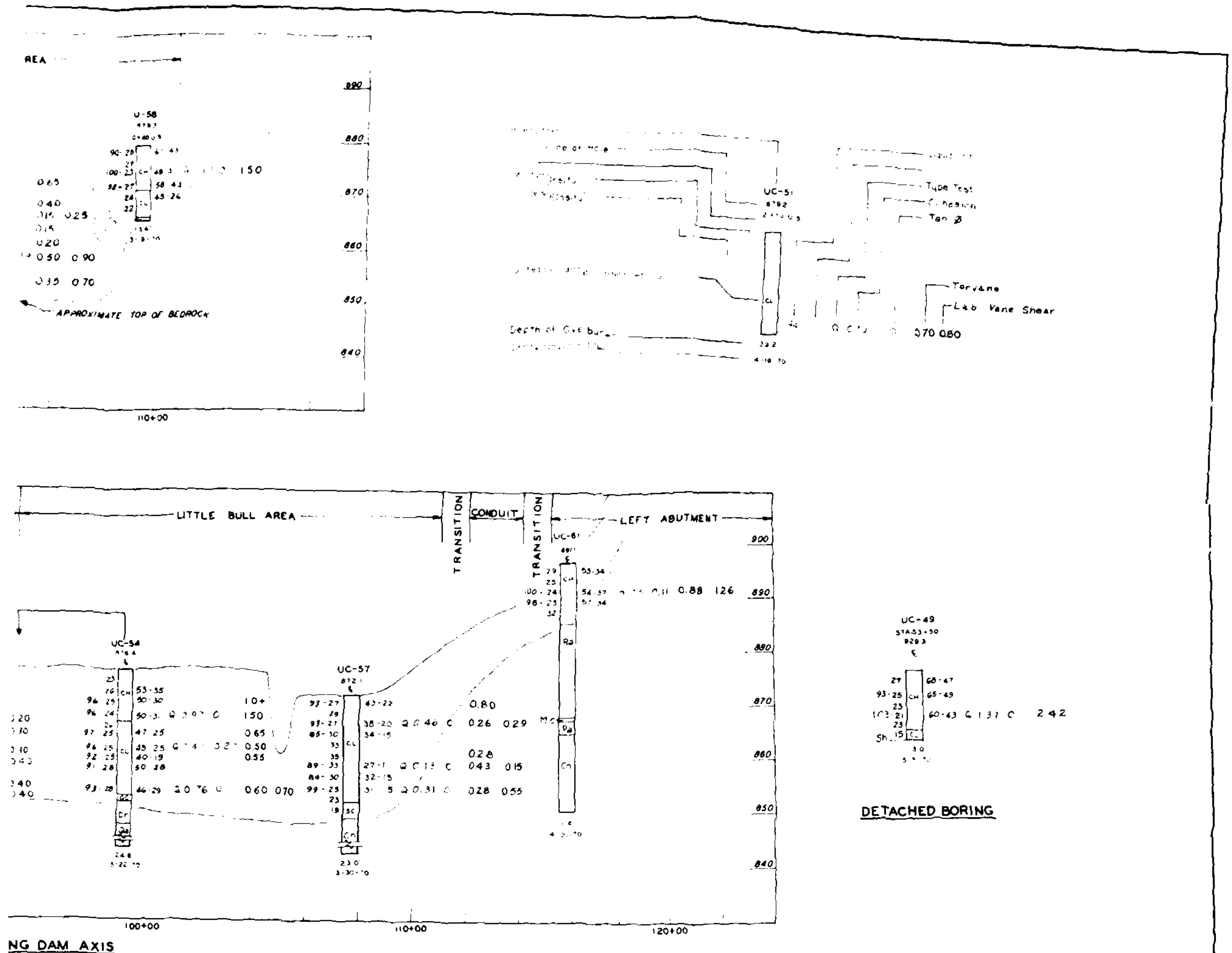
[illegible]

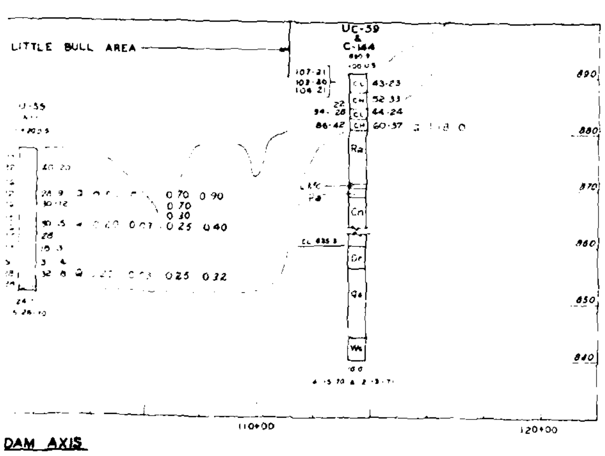
O-15-192

PLATE NO. 53



RIGHT ABUTMENT
MAIN VALLEY
LITTLE BULL AREA
U-136
U-56
U-58
APPROXIMATE EXISTING GROUND SURFACE
APPROXIMATE TOP OF BEDROCK
80+00
90+00
100+00
110+00
PROFILE-200 FEET DOWNSTREAM OF DAM AXIS
TRANSITION
CONDUIT
LEFT
UC-50
U-52
U-53 & C-141
UC-54
UC-57
70+00
PROFILE-ALONG DAM AXIS
UC-51
UC-135
U-55
UC-59 & C-144
120+00
PROFILE-200 FEET UPSTREAM OF DAM AXIS





SYM	DESCRIPTION	DATE	APP'D
	REVISIONS		

OSAGE RIVER BASIN

HILLSDALE LAKE

BIG BULL CREEK

2

FOUNDATION STRENGTH PROFILES "Q" TESTS

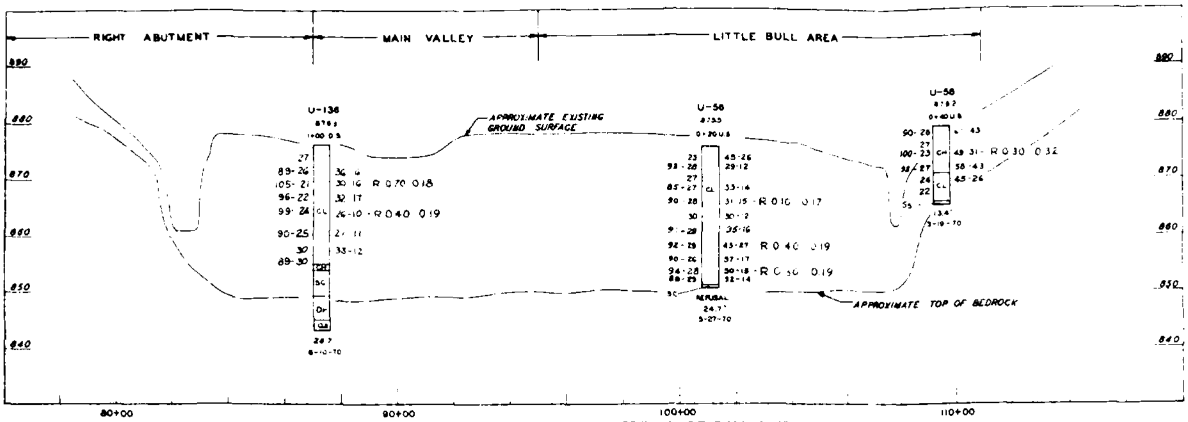
In 60 sheets — Sheet No 9 — Scale as shown

CORPS OF ENGINEERS
KANSAS CITY DISTRICT

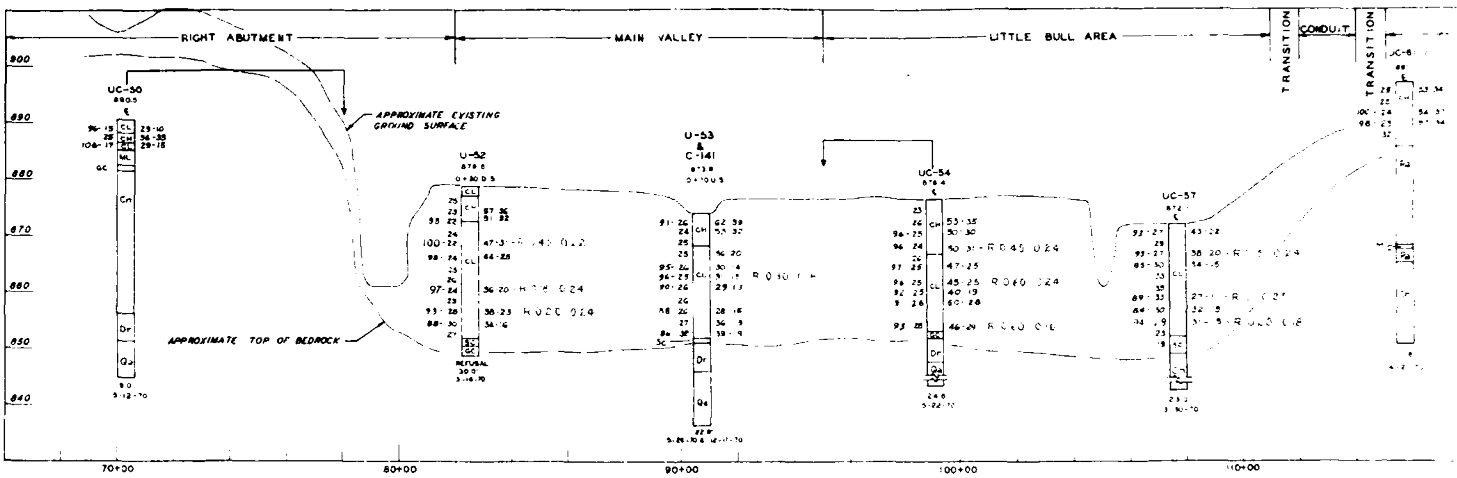
U. S. ARMY
MARCH 1971

Submitted — Recommended — Approved

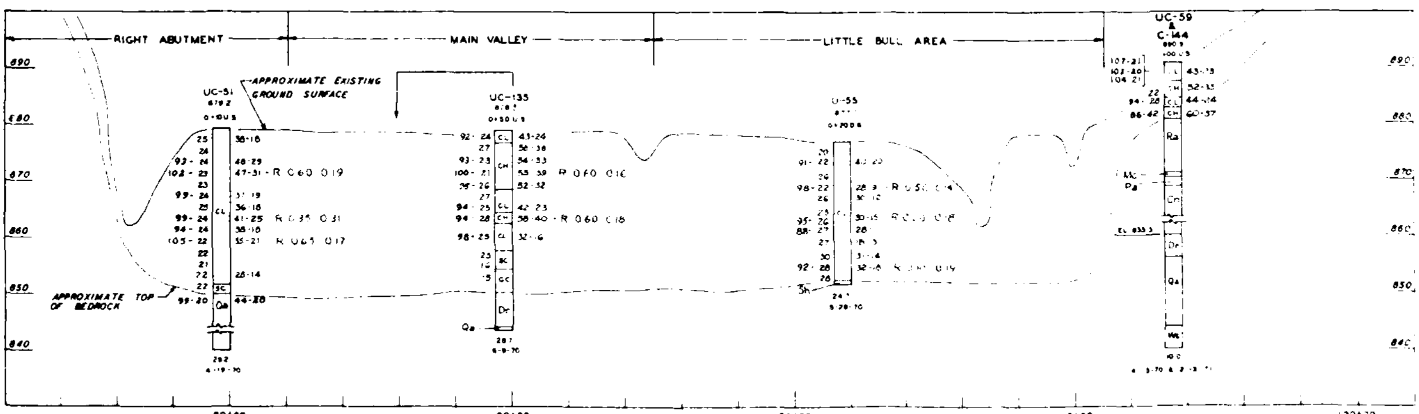
PLATE NO 54



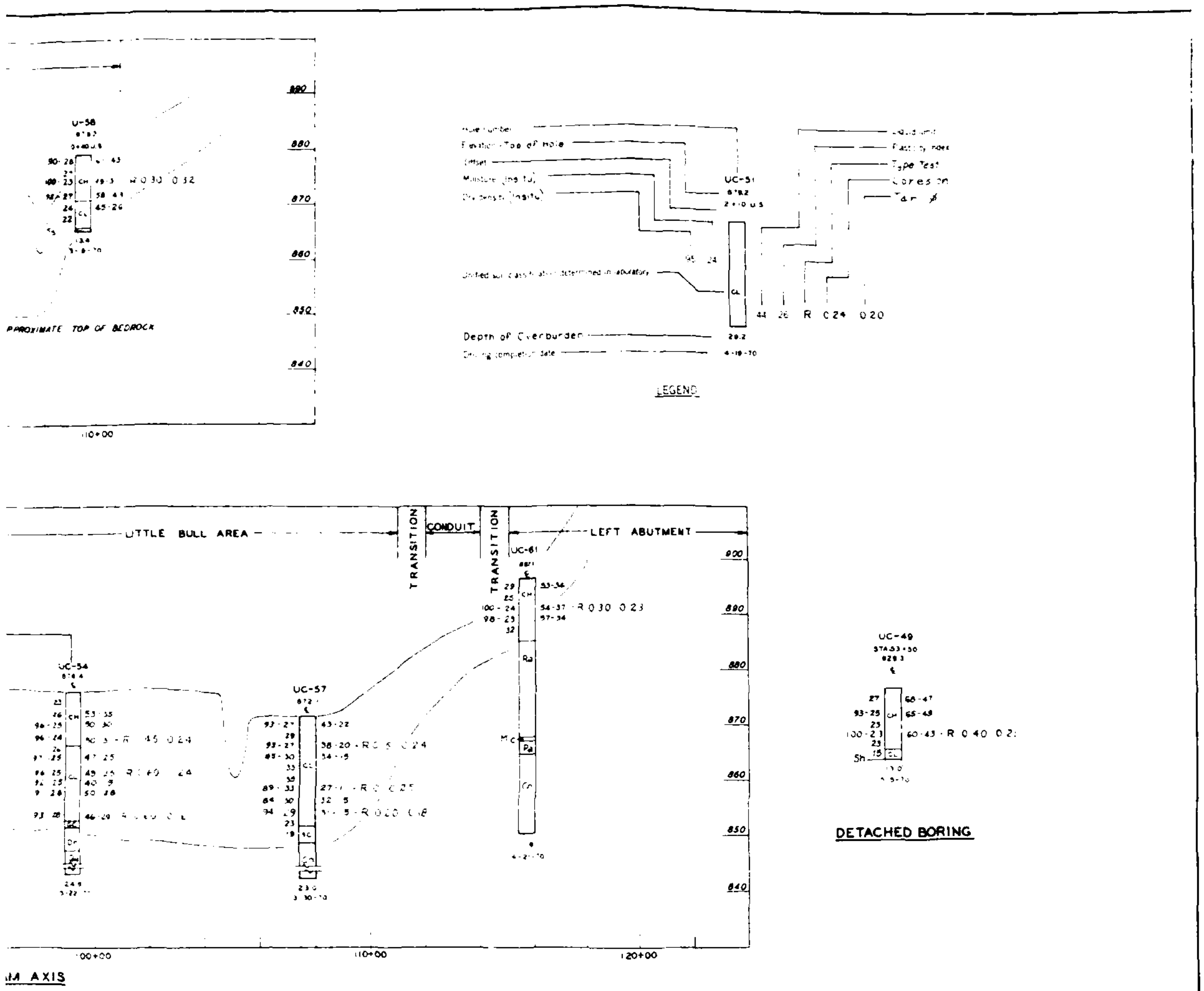
PROFILE-200 FEET DOWNSTREAM OF DAM AXIS

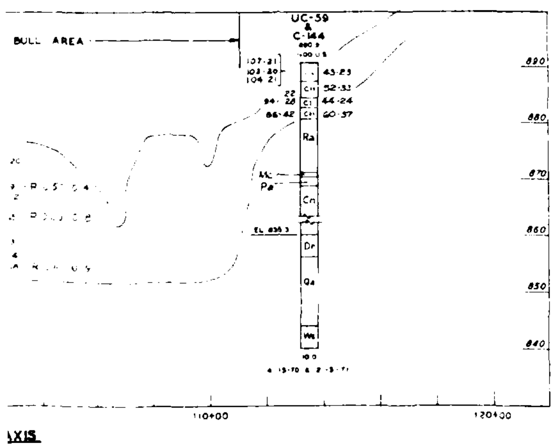


PROFILE-ALONG DAM AXIS



PROFILE-200 FEET UPSTREAM OF DAM AXIS





DESCRIPTION
REVISIONS
DATE

OSAGE RIVER BASIN

HILLSDALE LAKE

BIG BULL CREEK

FOUNDATION STRENGTH PROFILES
"R" TESTS

In 60 sheets

Sheet No 10

Scale as shown

CORPS OF ENGINEERS
KANSAS CITY DISTRICT

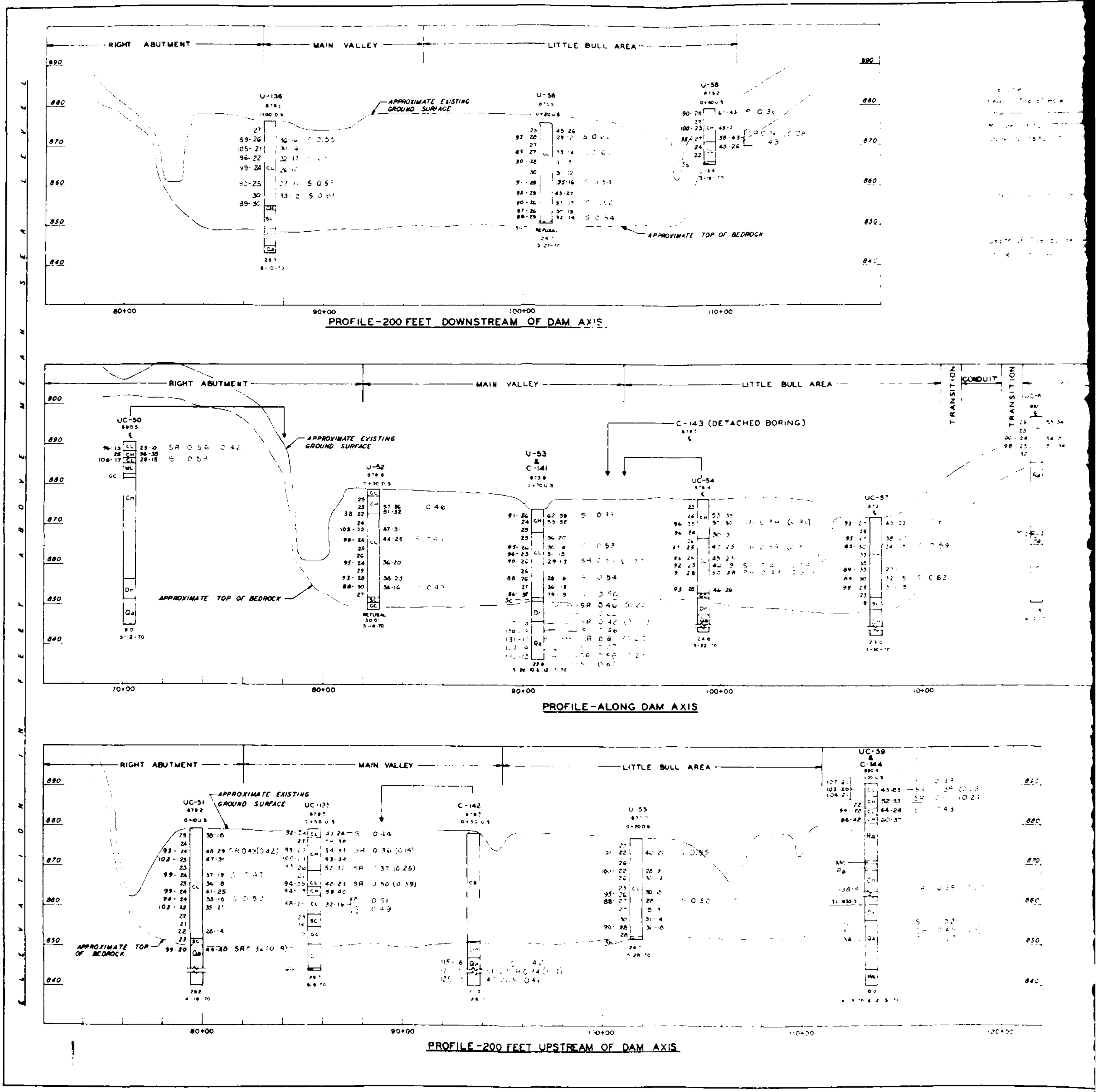
U.S. ARMY

MARCH 1971

RHB JFV RFO

DM-7 0-15-194

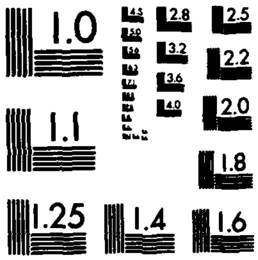
PLATE NO 55

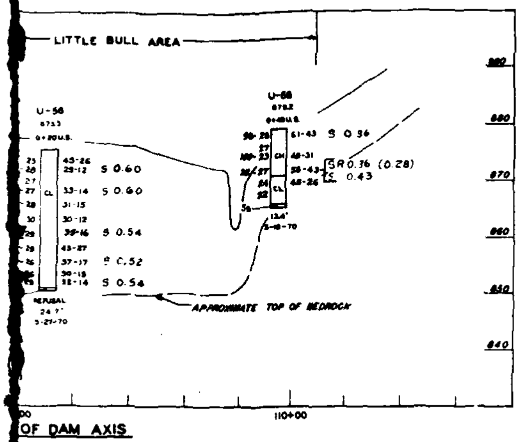


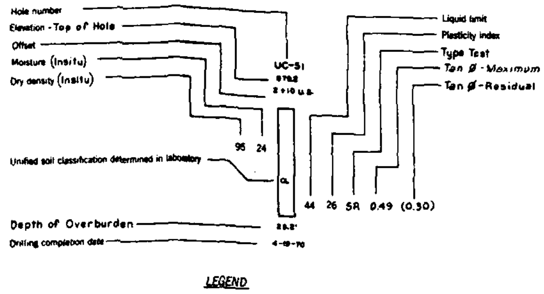
RIGHT ABUTMENT
MAIN VALLEY
LITTLE BULL AREA
APPROXIMATE EXISTING GROUND SURFACE
APPROXIMATE TOP OF BEDROCK
U-136
U-56
U-58
890
880
870
860
850
840
80+00
90+00
100+00
110+00
PROFILE-200 FEET DOWNSTREAM OF DAM AXIS
TRANSITION
CONDUIT
C-143 (DETACHED BORING)
UC-50
U-52
U-53 & C-141
UC-54
UC-57
REFUSAL
900
70+00
PROFILE-ALONG DAM AXIS
UC-51
UC-135
C-142
U-55
UC-59 & C-144
120+00
PROFILE-200 FEET UPSTREAM OF DAM AXIS
ELEVATION IN FEET ABOVE MEAN SEA LEVEL

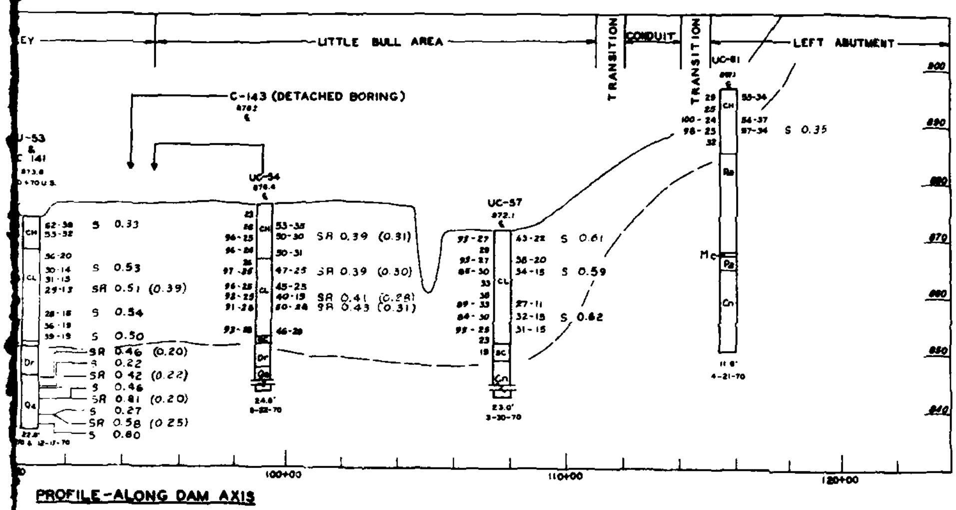
AD-A169 863 MULTIPLE-PURPOSE PROJECT OSAGE RIVER BASIN BIG BULL CREEK KANSAS HILLSDAL..(U) CORPS OF ENGINEERS KANSAS CITY MO KANSAS CITY DISTRICT F C WALBERG ET AL. SEP 84 3/4

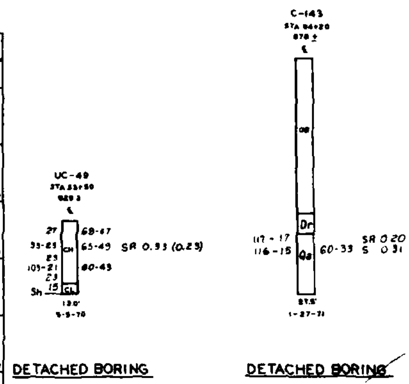
UNCLASSIFIED F/G 13/2 NL


1.0
4.5
5.0
5.6
2.8
3.2
3.6
4.0
2.5
2.2
2.0
1.1
1.8
1.25
1.4
1.6

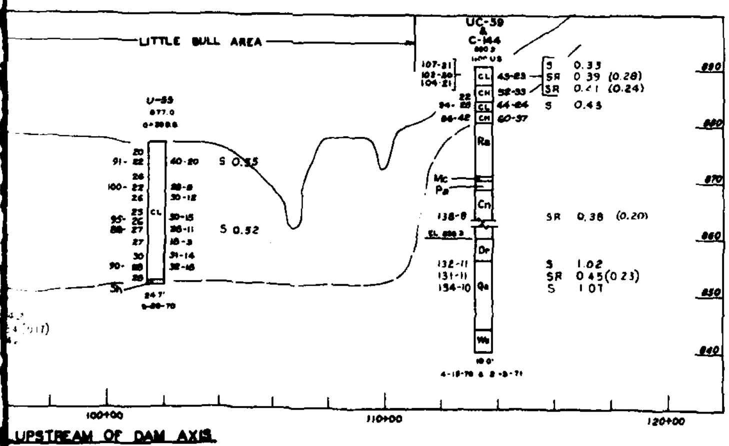








NOTE:
Direct Shear Tests run under normal strains to 0.50 inch are denoted by the symbol - S. Tests run at large strains to 2.5 or 3.0 inches are denoted by the symbol - SR.



SYM.	DESCRIPTION	DATE	APP'D.

REVISIONS

OSAGE RIVER BASIN

HILLSDALE LAKE

BIG BULL CREEK

FOUNDATION STRENGTH PROFILES
"S" TESTS

In 60 sheets — Sheet No. 11 — Scale as shown

CORPS OF ENGINEERS
KANSAS CITY DISTRICT

U. S. ARMY
MARCH 1971

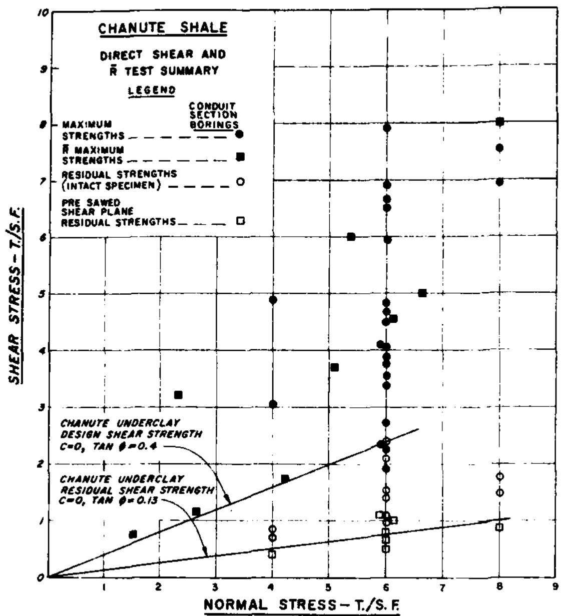
Submitted — Recommended — Approved

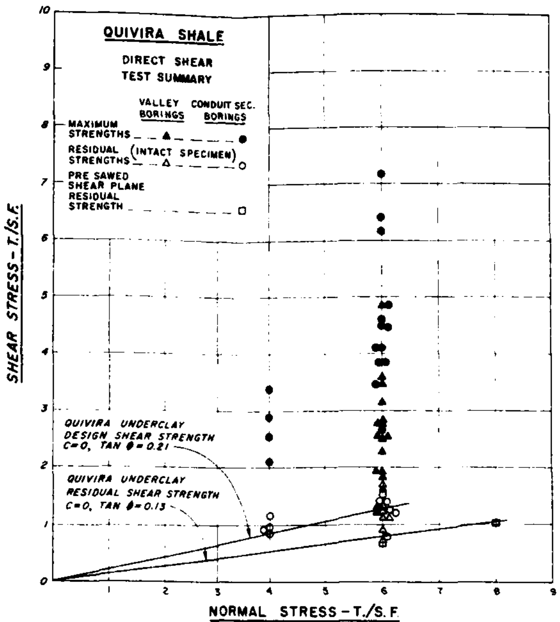
COMPILED BY R.K.B. — DRAWN BY J.A.M. — CHECKED BY R.F.D.

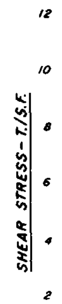
DM-7

FILE NO. 0-15-195

PLATE NO. 56





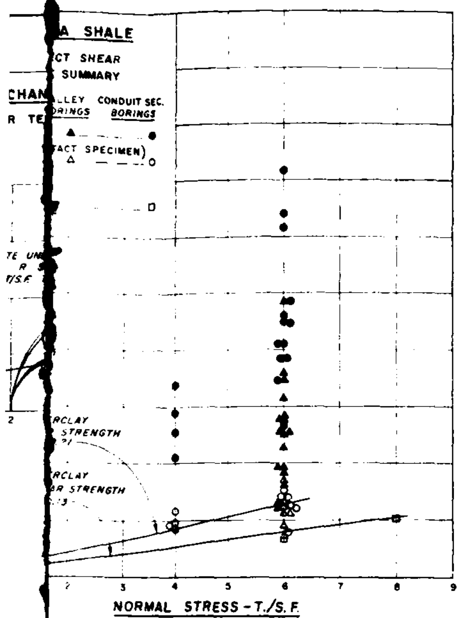


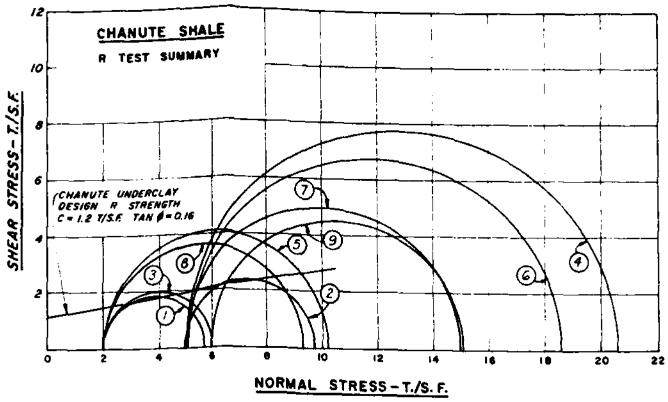
CHANUTE SHALE TEST SUMMARY

HOLE NO.	LOCATION	SAMPLE NO.	SAMPLE DEPTH	TYPE OF TEST	INITIAL CONDITIONS DRY DENSITY	MOISTURE CONTENT	% SATURATION	NORMAL STRESS	PEAK TAN ø	RESIDUAL TAN ø	COMMENTS
UC-59	CONDUIT SEC.	8	51.8-53.1	DIRECT SHEAR	138.0	8.0	100	6.0	0.39	0.23	
				" "	138.0	8.0	100	6.0	0.38	0.18	
U-60	CONDUIT SEC.	3	38.0-38.6	" "	129.0	7.5	63	6.0	0.78	0.34	
				" "	129.0	7.5	62	6.0	1.15	0.40	
		5	45.3-45.8	" "	128.5	10.5	100	6.0	0.59		
				" "	128.5	10.5	100	6.0	0.56		
		7	54.2-54.5	" "	132.0	10.5	98	6.0		0.08	PRE-SAWED
				" "	132.0	10.5	98	6.0		0.17	SHEAR PLANE
C-145	CONDUIT SEC.	13	33.3-34.9	" "	126.3	11.8	93	4.0	0.76	0.18	
				" "	125.2	13.1	99	6.0	1.11	0.16	
				" "	124.6	12.6	94	8.0	0.87	0.19	TEST ON LOW ANGLE
		13	33.7-34.1	" "	119.6	13.9	90	6.0	0.46		SLICKENSIDE
		14	34.9-36.8	" "	121.6	14.1	89	4.0		0.10	PRE-SAWED
				" "	124.0	13.0	89	6.0		0.13	SHEAR
				" "	124.9	13.7	86	8.0		0.11	PLANE
		21 & 22	48.0	R̄	133.1	11.2	100	1.5	0.48		
				"	137.6	9.8	93	4.2	0.41		
C-146	CONDUIT SEC.	5	29.4-30.9	DIRECT SHEAR	134.2	10.4	100	4.0	1.22	0.21	
				" "	133.9	9.5	95	6.0	1.32	0.25	
				" "	131.8	9.5	86	8.0	0.94	0.22	
				" "	130.9	10.8	96	6.0	0.80		STRESS
		6	30.9-32.9	" "	121.8	14.3	95	6.0	1.09		CONTROLLED
				" "	121.7	14.9	99	6.0	0.99		
				" "	119.2	16.2	100	6.0	0.63		
C-151	CONDUIT SEC.	1	14.3-14.5	" "	123.0	13.5	86	6.0	0.67	0.25	MUNCIE CREEK SHALE
		3	18.5-18.6	" "	126.0	13.0	94	6.0	0.32		
		16	34.0-34.4	" "	125.3	13.0	95	6.0		0.18	PRE SAWED
				" "	125.3	13.0	95	6.0		0.12	SHEAR PLANE
		18	37.0-37.4	" "	122.0	14.5	92.5	6.0	0.68		
				" "	122.0	14.5	92.5	6.0	0.75		
		19	38.9-39.1	" "	124.5	13.0	96	6.0	0.65		
				" "	124.5	13.0	96	6.0	0.69		
C-152	CONDUIT SEC.	1	48.0-50.0	R̄	121.0	13.5	93	2.7	0.43		DEPTH ALONG 45° ANGLE HOLE
				"	124.9	13.9	100	8.0	1.00		
		3	52.5-54.7	"	117.1	10.9	65	2.3	1.37		
				"	124.2	11.7	85	5.4	1.12		
		6	58.2-60.5	"	128.4	10.4	84	6.6	0.75		
		7	60.5-62.7	"	142.9	7.1	97	5.1	0.73		
				"	145.5	6.8	92	6.1	0.75		

QUIVIRA SHALE TEST SUMMARY

HOLE NO	LOCATION	SAMPLE NO.	SAMPLE DEPTH	TYPE OF TEST	INITIAL CONDITIONS DRY DENSITY	MOISTURE CONTENT	% SATURATION	NORMAL STRESS	PEAK TAN ø
U-51	VALLEY	15	29.0-30.2	DIRECT SHEAR	99.5	20.0	74	6.0	0.3[illegible]
C-141	VALLEY	1	28.0-28.3	" "	117.0	14.0	85	6.0	0.46
		1	28.7-28.8	" "	130.0	11.0	100	6.0	0.38
				" "	130.0	11.0	100	6.0	0.53
		2	29.7-29.8	" "	130.0	9.5	82	6.0	0.22
		2	30.1-30.3	" "	128.0	9.5	78	6.0	0.42
		3	31.3-32.0	" "	130.0	12.0	97	6.0	0.46
				" "	131.0	11.0	96	6.0	0.81
		5	34.9-35.3	" "	122[illegible]	9.0	75	6.0	0.27
				" "		8.0		6.0	0.58
		6	37.2-37.3	" "	130.0	12.0	100	6.0	0.60
C-142	VALLEY	1	31.7-31.9	" "	115.0	16.5	89	6.0	0.43
		2	34.0-34.3	" "	120.0	15.0	99	3.0	0.50
				" "	120.0	15.0	95	6.0	0.34
		3	34.9-35.3	" "	125.0	13.5	99	6.0	0.46
C-143	VALLEY	1	32.0-32.5	" "	117.5	17.0	100	6.0	0.21
		2	33.2-33.5	" "	116.0	15.5	94	6.0	0.31
				" "	116.0	15.5	94	6.0	0.32
		3	33.9-34.1	" "	114.0	14.5	79	6.0	0.42
C-144	CONDUIT SEC.	1	57.3-57.4	" "	132.0	11.5	100	6.0	1.03
		1	57.4-57.5	" "	131.0	11.0	100	6.0	0.45
		3	59.5-60.3	" "	134.0	10.0	95	6.0	1.20
				" "	135.0	9.0	92	6.0	1.07
C-145	CONDUIT SEC.	24	54.1-56.1	" "	133.5	11.0	100+	6.0	
				" "	135.1	9.9	92	8.0	
				" "	129.7	12.2	100+	6.0	0.69
C-146	CONDUIT SEC.	18	52.9-53.4	" "	130.5	10.0	8[illegible]	4.0	0.53
				" "	130.5	10.0	81	4.0	0.64
		18	53.6-53.8	" "	129.0	11.0	87	6.0	0.75
				" "	129.0	11.0	87	6.0	0.69
		19	55.6-55.9	" "	136.0	9.0		6.0	0.75
				" "	136.0	9.0		6.0	0.81
		19	55.9-56.0	" "	[illegible]	9.0	[illegible]	4.0	0.84
				" "	136.0	9.0	100	4.0	0.73
C-151	CONDUIT SEC.	29	54.7-55.0	" "	128.5	12.0	93	6.0	0.64
				" "	128.5	12.0	93	6.0	0.64
		30	55.9-56.1	" "	133.0	10.0	93	6.0	0.58
				" "	133.0	10.0	93	6.0	0.76



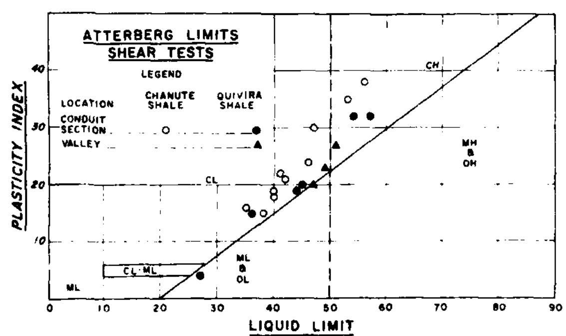


QUIVIRA SHALE TEST SUMMARY

LOCATION	SAMPLE NO.	SAMPLE DEPTH	TYPE OF TEST	INITIAL CONDITIONS DRY DENSITY	MOISTURE CONTENT	% SATURATION	NORMAL STRESS	PEAK TAN ϕ	RESIDUAL TAN ϕ	COMMENTS
[illegible]	15	29.0-30.2	DIRECT SHEAR	99.5	20.0	74	6.0	0.37	0.18	
[illegible]	1	28.0-28.3	" "	117.0	14.0	85	6.0	0.46	[illegible]	
		28.7-28.8	" "	130.0	11.0	100	6.0	0.38		
			" "	130.0	11.0	100	6.0	0.53		
	2	29.7-29.8	" "	130.0	9.5	82	6.0	0.22		SHEAR ON SOFT SEAM
	2	30.1-30.3	" "	128.0	9.5	78	6.0	0.42	0.22	
	3	31.3-32.0	" "	130.0	12.0	97	6.0	0.46		
			" "	131.0	11.0	96	6.0	0.81	0.18	
	5	34.9-35.3	" "	127.[illegible]	9.0	75	6.0	0.27		SHEAR ON
			" "		8.0	-	6.0	0.58	0.28	OPEN JOINT
	6	37.2-37.3	" "	130.0	12.0	100	6.0	0.60		
VALLEY	1	31.7-31.9	" "	115.0	16.5	89	6.0	0.45		
	2	34.0-34.3	" "	120.0	15.0	99	3.0	0.50	0.24	
			" "	120.0	15.0	95	6.0	0.34	0.16	
	3	34.9-35.3	" "	125.0	13.5	99	6.0	0.46		
VALLEY	1	32.0-32.5	" "	117.5	17.0	100	6.0	0.21	0.12	SHEAR ON SOFT SEAM
	2	33.2-33.5	" "	116.0	15.5	94	6.0	0.31		
			" "	116.0	15.5	94	6.0	0.32		
	3	33.9-34.[illegible]	" "	114.0	14.5	79	6.0	0.42	0.20	
CONDUIT SEC	1	57.3-57.4	" "	132.0	11.5	100	6.0	1.03		
	1	57.4-57.5	" "	131.0	11.0	100	6.0	0.45	0.23	
	3	59.5-60.3	" "	134.0	10.0	95	6.0	1.20		
			" "	135.0	9.0	92	6.0	1.07		
CONDUIT SEC	24	54.[illegible]-56.1	" "	133.5	11.0	100+	6.0		0.11	PRE SAWED
			" "	135.1	9.9	92	8.0		[illegible]	SHEAR PLANE
			" "	129.7	12.2	100+	6.0	0.69	0.13	
CONDUIT SEC	18	52.9-53.4	" "	130.5	10.0	81	4.0	0.53	0.24	
			" "	113.5	10.0	81	4.0	0.64	0.21	
	18	53.6-53.8	" "	129.0	11.0	87	6.0	0.75	0.18	
			" "	129.0	11.0	87	6.0	0.69	0.20	
	19	55.6-55.9	" "	136.0	9.0		6.0	0.75	0.25	
			" "	136.0	9.0		6.0	0.81	0.20	
	19	55.9-56.0	" "	[illegible]	9.0		4.0	0.84	0.22	
			" "	136.0	9.0	100	4.0	0.73	0.28	
CONDUIT SEC	29	54.7-55.0	" "	129.5	12.0	93	6.0	0.64		
			" "	128.5	12.0	93	6.0	0.64		
	30	55.9-56.1	" "	133.0	10.3	93	6.0	0.58		
			" "	133.0	10.3	93	6.0	0.76		

CHANUTE SHALE R TEST SUMMARY

TEST NO.	HOLE NO.	LOCATION	SAMPLE NO.	SAMPLE DEPTH	INITIAL CONDITIONS DRY DENSITY	MOISTURE CONTENT	SATURATION
1	C-145	CONDUIT SEC	21 & 22	48.0	133.1	11.2	100
2					137.6	9.8	93
3	C-152	" "	1	48.0-50.0	121.0	13.5	93
4					124.9	13.9	100
5			3	52.5-54.7	117.1	10.9	65
6					124.2	11.7	85
7			6	58.2-60.5	128.4	10.4	84
8			7	60.5-62.7	142.9	7.1	97
9					145.5	6.8	92



NOTE
Test results shown on this plate include those presented in DM 7 [illegible] additional testing for Supplement to DM 7

SYM	DESCRIPTION REVISIONS	DATE	APPD.

BIG BULL CREEK, KANSAS

HILLSDALE LAKE

TEST DATA SUMMARY FOUNDATION SHALES

In 1 sheet — Sheet No 1 — Scale as shown

CORPS OF ENGINEERS KANSAS CITY DISTRICT
U S ARMY DECEMBER 1971

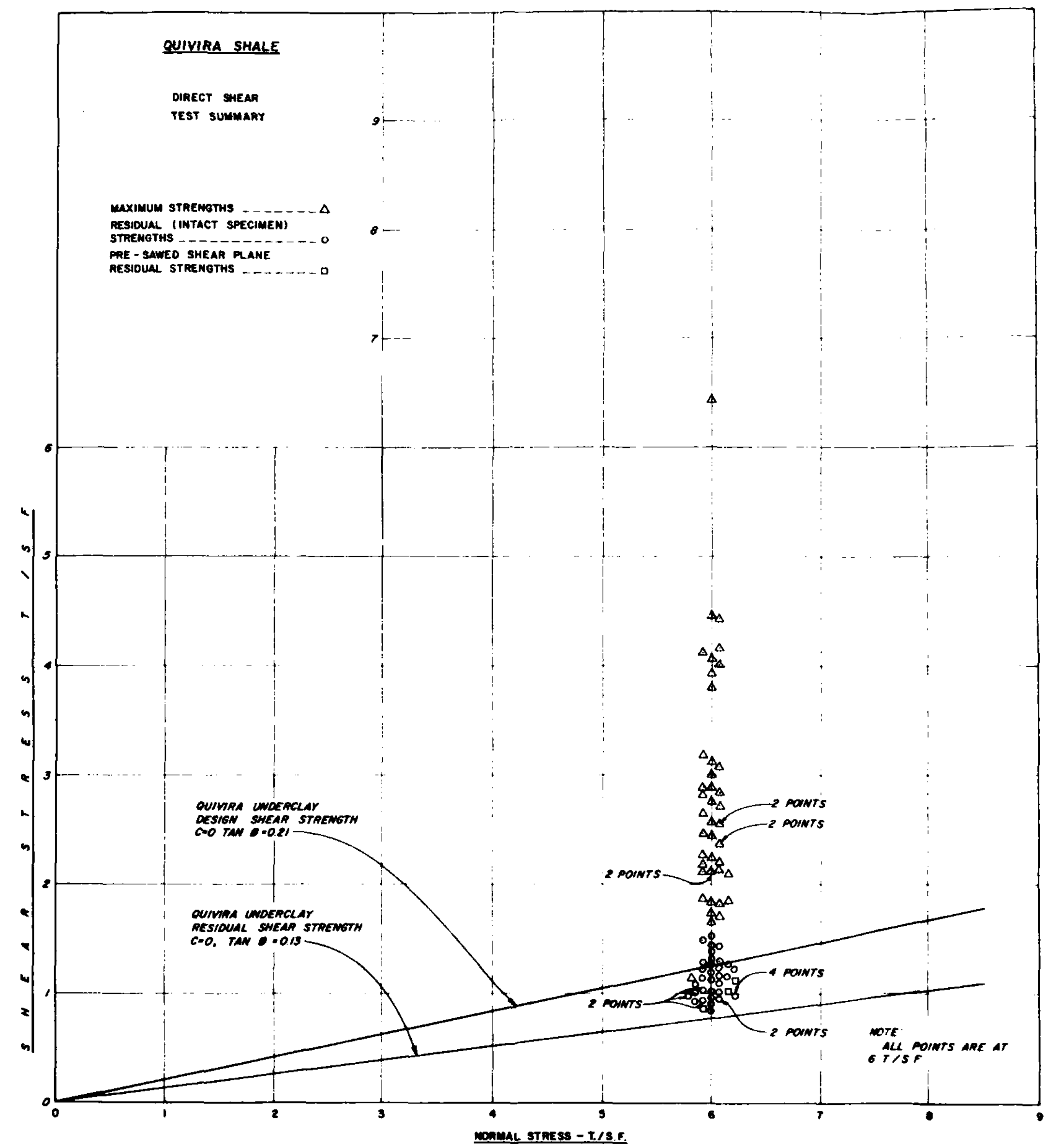
Submitted — Recommended — Approved

CHIEF, DAMS & FOUNDATIONS SECT. — CHIEF, FOUNDATIONS & MATLS. BR. — CHIEF, ENGINEERING DIVISION

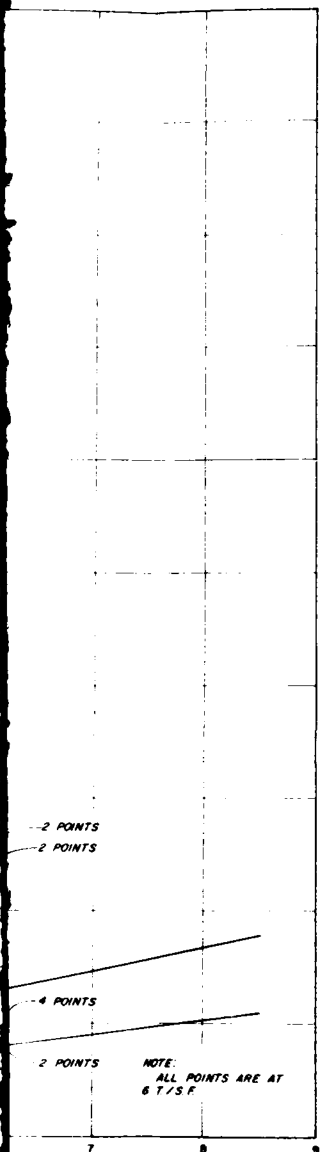
COMPILED BY W.G.A. — DRAWN BY F.C.L. — CHECKED BY R.F.D. — DM-7 — FILE NO. 0-15-307

2

PLATE NO.57



HOLE NUMBER	STATION	RANG
[illegible]	[illegible]	[illegible]
P-78-1	78+30	[illegible]
P-86-1	86+40	5+20
P-87-2	87+65	6+10
P-94-2	95+09	5+50
P-94-3	93+95	3+50
P-94-8	93+58	0+80
P-94-16	93+95	3+50
P-104-7	103+95	0+80
P-104-13	104+27	3+50
C-454	91+50	0+04
C-457	88+50	℄
TP-460	104+15	0+05
TP-461	102+80	0+05
TP-463	100+70	0+18.5
TP-464	100+67	0+18
TP-465	103+91	0+18.5
TP-469	94+22	0+18.5
TP-470	94+24	0+18
TP-471	94+18	0+18



QUIVIRA SHALE DIRECT SHEAR TEST SUMMARY

HOLE NUMBER	STATION	RANGE	SAMPLE NUMBER	SAMPLE DEPTH	DRY DENSITY	INITIAL CONDITIONS MOISTURE CONTENT	INITIAL CONDITIONS % SATURATION	LIQUID LIMIT	PEAK TAN θ	RESIDUAL TAN θ	COMMENTS
P-75-2	75+10	6+10U	1	24.1-24.6	102.8	23.3	94	56	0.40	—	
			1	24.1-24.6	100.7	23.6	91	56	0.35	—	
			1	24.1-24.6	104.8	21.0	89	56	—	0.14	Pre-sawed shear plane
			1	24.1-24.6	107.2	21.3	95	56	0.41	0.16	
P-78-1	78+30	3+60U	2	27.0-27.2	115.2	17.3	93	54	0.35	0.18	
			2	27.0-27.2	115.7	17.0	92	54	0.41	0.16	
			2	27.4-27.6	117.0	17.7	99	54	0.38	0.16	
			2	27.5-27.7	123.1	14.2	93	54	—	0.16	No peak on θ -
			2	27.0-27.2	117.0	17.3	97	54	—	0.21	Equipment malfunction.
P-86-1	86+40	3+20D	1	30.8-31.3	121.6	14.0	92	42	0.66	—	
			1	30.8-31.3	123.9	12.9	90	42	0.69	—	
			1	30.8-31.3	123.4	12.9	89	42	0.68	0.24	
			1	30.8-31.3	124.4	13.8	98	42	0.67	0.22	
			3	33.2-33.4	118.8	17.8	100*	47	0.74	0.20	
			3	33.2-33.4	127.2	13.9	100	47	0.74	0.16	
P-87-2	87+65	6+10D	1	31.8	110.2	14.8	73	44	0.44	0.20	
			1	31.8	120.8	15.3	99	44	1.07	0.25	
			2	33.6	117.3	15.4	89	50	0.43	0.17	
			2	33.6	112.8	17.6	90	50	0.38	0.17	
			2	33.4	106.2	20.8	91	50	—	0.17	No peak for θ - Equipment malfunction
P-94-2	95+09	5+50U	1	28.8-29.3	110.6	15.4	74	42	—	0.19	Pre-sawed
			1	28.8-29.3	115.8	16.1	89	42	—	0.17	shear plane
			2	29.4	116.2	15.6	84	52	0.35	0.16	
			2	29.4	115.8	15.9	85	52	0.31	0.16	
P-94-3	93+95	3+50U	1	29.5-29.7	114.3	16.2	86	46	0.40	—	
			1	29.5-29.7	116.9	16.9	95	46	0.51	0.20	
			1	29.5-29.7	118.4	16.4	96	46	0.48	0.19	
			2	30.9-31.2	105.8	20.0	89	54	0.35	0.23	
			2	30.9-31.2	117.0	17.2	100*	54	0.36	0.16	
P-94-8	93+58	0+80U	1	30.6	117.2	16.7	98	44	0.70	0.25	
			1	30.6	114.5	15.8	86	44	0.53	0.22	
P-94-16	93+95	3+50D	2	29.8	117.1	17.4	100*	55	0.46	0.20	
			2	29.8	119.4	15.7	97	55	0.46	0.16	
P-104-7	103+95	0+80U	1	28.8	114.4	18.2	100	52	0.28	0.14	
			1	28.8	113.9	17.3	94	52	0.30	0.16	
P-104-13	104+27	3+50D	2	30.8	116.4	15.8	90	58	—	0.17	No peak tan θ - Equipment malfunction
C-454	91+50	0+04D	1	4.10-5.60	112.5	18.0	90	52	0.47	0.19	6" was drilled from top of
C-457	88+50	℄	2	6.00-7.70	113.9	16.5	88	57	0.20	0.16	Drum Limestone
TP-460	104+15	0+05D	1	0.87-1.33	114.5	18.0	94	51	0.29	0.15	6" cylinder handcut from bottom
TP-461	102+80	0+05U	1	0.83-1.11	113.5	17.7	91	52	0.28	0.16	of cutoff trench
			1	1.11-1.39	115.6	16.1	87	52	0.47	—	12" block handcut from bottom of
			1	1.39-1.67	120.6	15.0	92	49	0.43	—	cutoff trench
TP-463	100+70	0+18.50	1	0.30	111.3	17.2	87	48	0.43	0.21	
			1	0.50	114.2	17.6	95	57	0.50	0.18	
TP-464	100+67	0+18.50	1	0.10	114.0	15.6	84	43	0.52	—	
			1	0.30	116.4	16.0	91	49	0.37	0.19	6" cylinders handcut from
TP-465	103+91	0+18.50	1	0.25	109.1	19.7	92	44	0.63	0.24	sidewall of cutoff trench
			1	0.40	105.9	20.9	90	55	0.48	0.21	
TP-469	94+22	0+18.50	1	0.40	109.9	19.8	92	65	0.31	0.17	
TP-470	94+24	0+18.50	1	0.40	110.7	19.9	95	63	0.36	0.17	
TP-471	94+18	0+18.50	1	0.50	106.7	19.9	87	64	0.31	0.16	

NOTE
ALL TESTS WERE RUN WITH A NORMAL STRESS OF 6 T/S.F

SYM	DESCRIPTION	DATE	APP'D
	REVISIONS		

BIG BULL CREEK, KANSAS

HILLSDALE LAKE

2

TEST DATA SUMMARY
QUIVIRA SHALE (1977 TESTS)

In 1 sheet — Sheet No. 1 — Scale as shown

CORPS OF ENGINEERS
KANSAS CITY DISTRICT

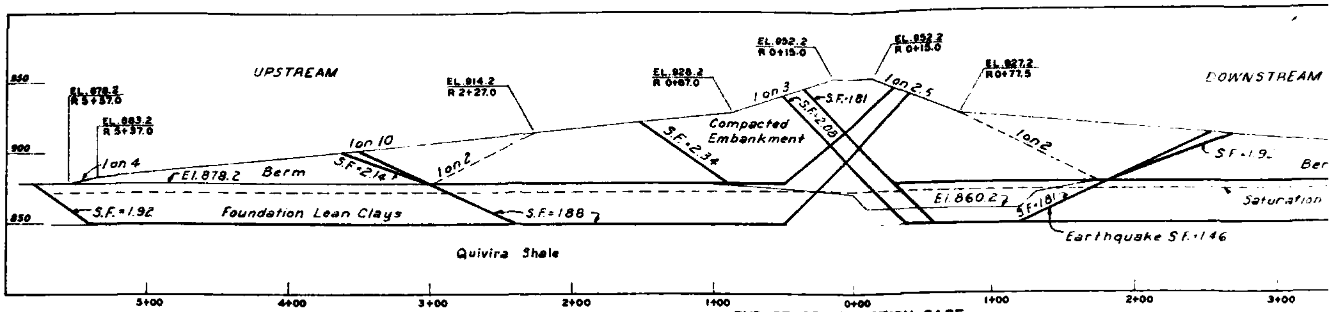
U. S. ARMY
JANUARY 1978

Submitted — Recommended — Approved

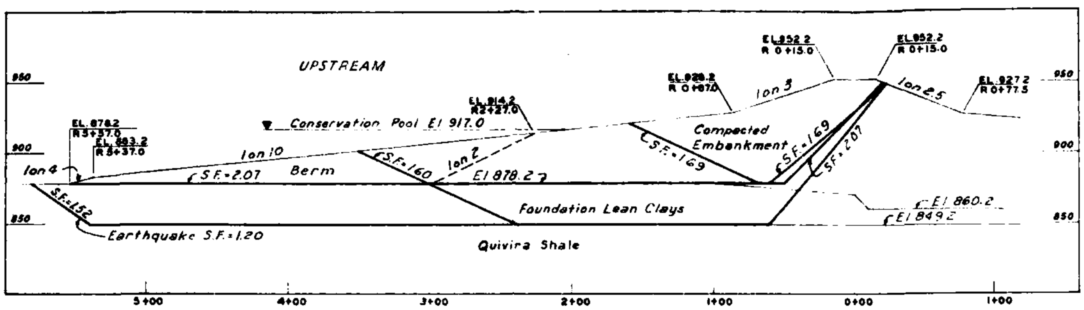
CHIEF, DAMS & FOUNDATIONS SECT — CHIEF, FOUNDATIONS & MATLS BR — CHIEF, ENGINEERING DIVISION

COMPILED BY: SAD — DRAWN BY: JPM — CHECKED BY: RGF — DM-7 — FILE NO. 0-15-673

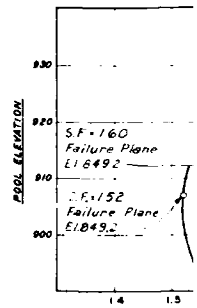
PLATE NO. 59

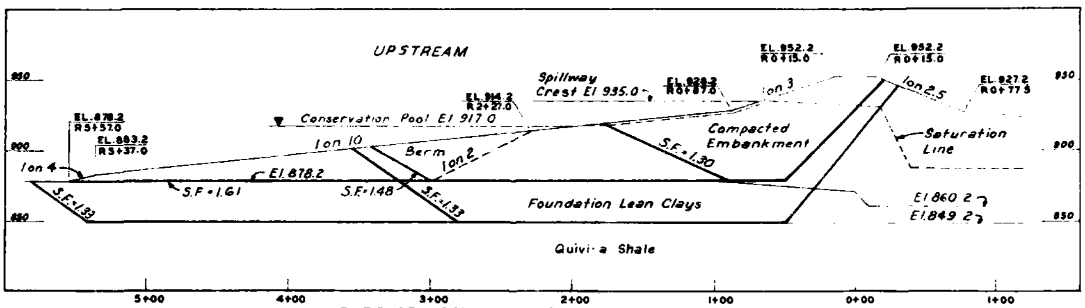


END OF CONSTRUCTION CASE



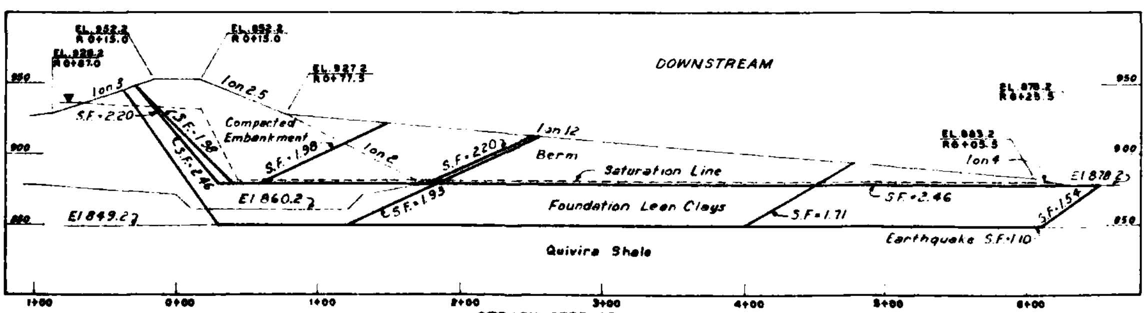
PARTIAL POOL CASE





RAPID DRAWDOWN CASE (FROM SPILLWAY CREST)

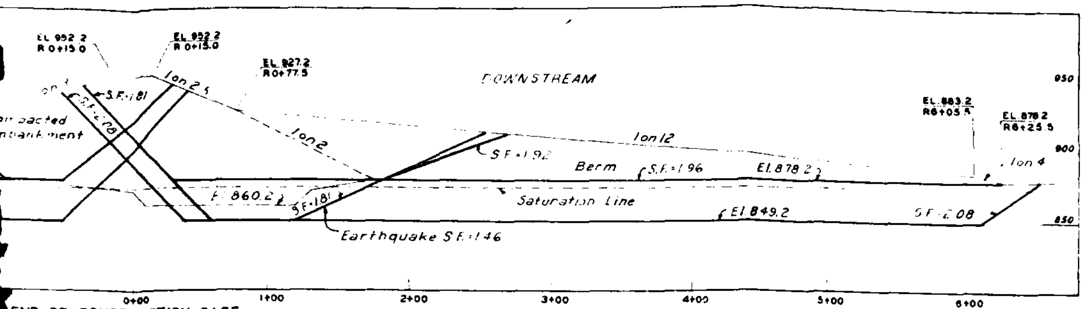
RAPID DRAW	
EL OF FAILURE PLANE	SAFETY FROM SPILLWAY CREST
878	1.30
849	1.33



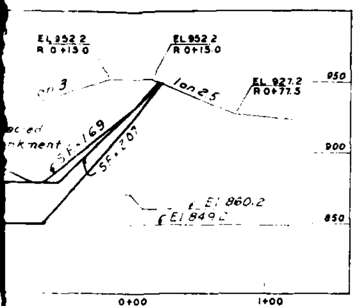
STEADY SEEPAGE CASE

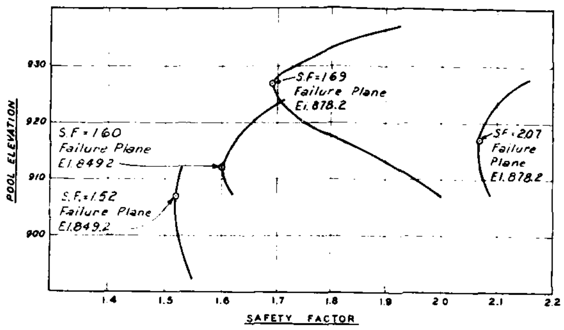
CAS
End of Cons
Rapid Draw From Spillw
Rapid Draw From Maximu
Partial Poo
Steady Seep
Earthquake

* For Steady S

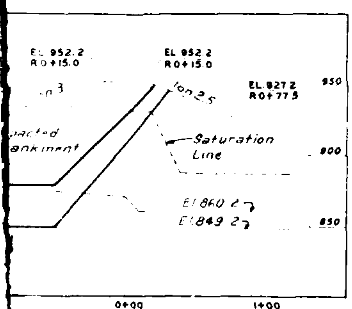


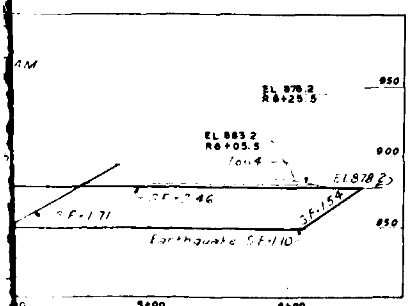
END OF CONSTRUCTION CASE





PARTIAL POOL CASE





RAPID DRAWDOWN		
EL OF FAILURE PLANE	SAFETY FACTOR FROM SPILLWAY CREST	SAFETY FACTOR FROM MAXIMUM SURCHARGE
878	1.30	1.21
849	1.33	1.28

PHYSICAL SOIL CONSTANTS								
MATERIAL	UNIT WEIGHT P/CF		DESIGN SHEAR STRENGTHS Q		R		S	
	SAT	DRAINED	C (TSF)	TAN Ø	C (TSF)	TAN Ø	C (TSF)	TAN Ø
Compacted Embankment	125	120	.700	.000	.200	.180	.000	.450
Berm Fill	115	110	.100 / .400	.000 / .000	.100	.100	.000	.350
Fdn Lean Clays	115	110	.200 / .300	.200 / .000	.300	.200	.000	.450
Quivira Underclay	140		—	—	—		.000	.210

STABILITY STUDIES USING RESIDUAL STRENGTHS FOR FOUNDATION OVERBURDEN AND SHALES	
CASE	SAFETY FACTOR
Steady Seepage	1.06
Partial Pool	1.09
Rapid Drawdown From Spillway Crest	0.94
Rapid Drawdown From Max Surcharge	0.90

SAFETY FACTORS		
CASE	REQUIRED	ACTUAL
End of Construction	1.4	1.81
Rapid Drawdown From Spillway Crest	1.2	1.30
Rapid Drawdown From Maximum Surcharge	1.0	1.21
Partial Pool	1.5	1.52
Steady Seepage	1.5	1.54
Earthquake	1.0	1.10*

*For Steady Seepage Case

SYM DESCRIPTION DATE APP'D

REVISIONS

OSAGE RIVER BASIN

HILLSDALE LAKE

BIG BULL CREEK

EMBANKMENT STABILITY ANALYSIS SUMMARY
LOWER RIGHT ABUTMENT-STA 81+00

In 5 sheets Sheet No 1 Scale as shown

CORPS OF ENGINEERS
KANSAS CITY DISTRICT

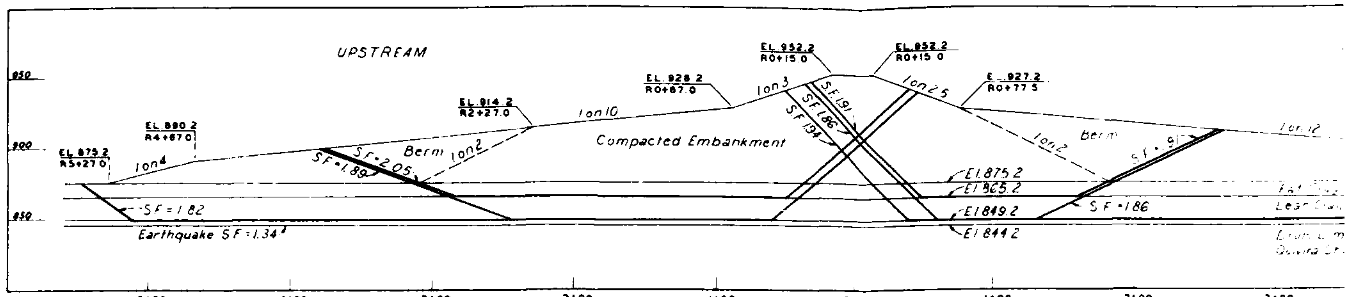
U S ARMY
MARCH 1971

Submitted Recommended Approved

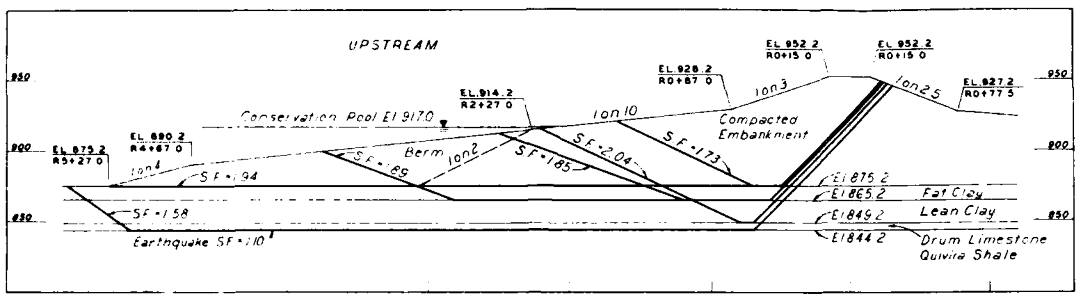
CHIEF DAMS & FOUNDATIONS SECT CHIEF FOUNDATIONS & MATLS BR CHIEF ENGINEERING DIVISION

COMPILED BY RKB-WGA DRAWN BY JAM CHECKED BY RF

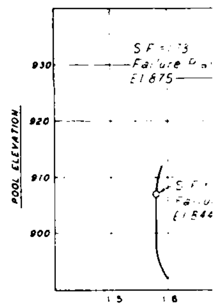
FILE NO. C-15-247

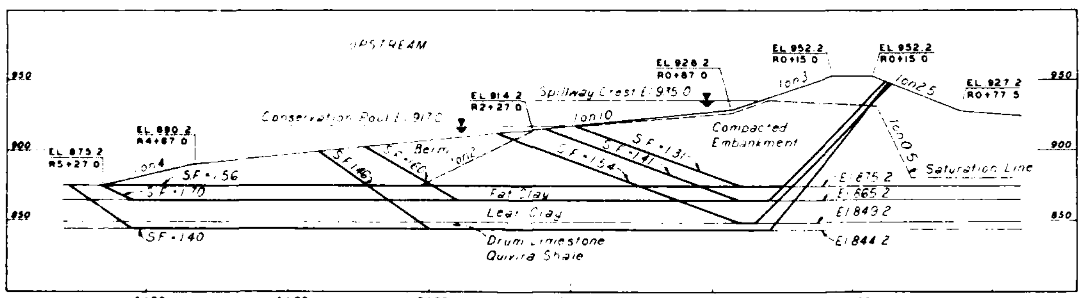


END OF CONSTRUCTION CASE



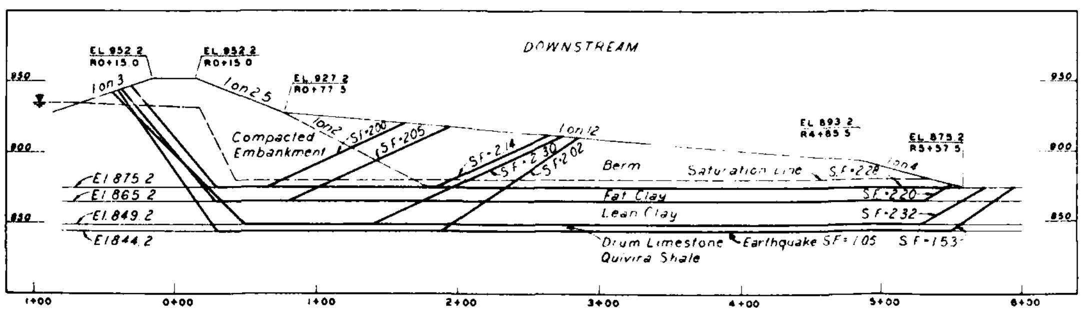
PARTIAL POOL CASE





RAPID DRAWDOWN CASE (FROM SPILLWAY CREST)

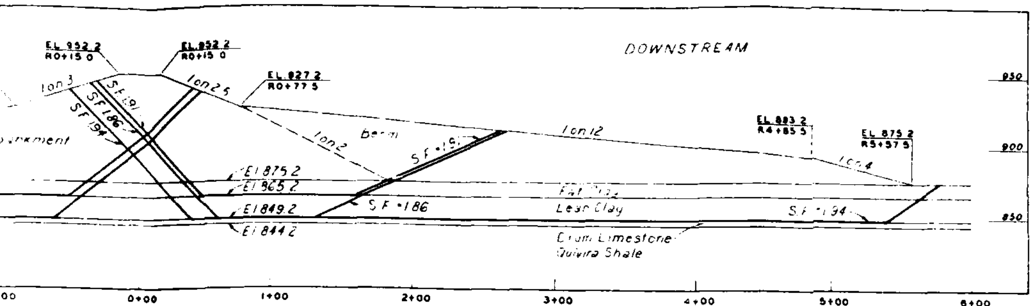
RAPID DRAWDOW...	
EL. OF FAILURE PLANE	SAFETY FA... FROM SPILLWAY CREST
875	3·
865	4·
849	5 4
844	4·



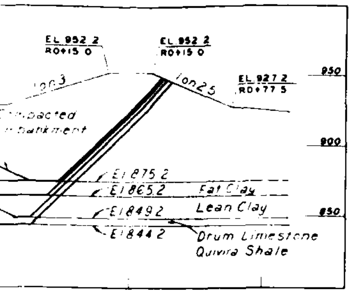
STEADY SEEPAGE CASE

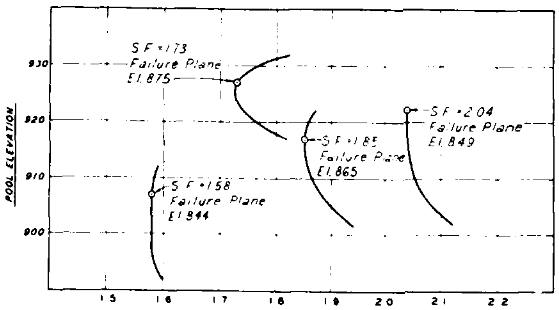
CASE
End of Construct...
Rapid Drawdown ... Crest
Rapid Drawdown ... Surcharge
Partial Pool
Steady Seepage
Earthquake

*For Steady Seep...



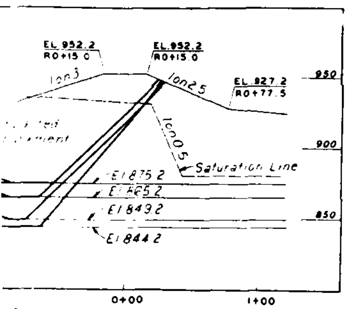
END OF CONSTRUCTION CASE





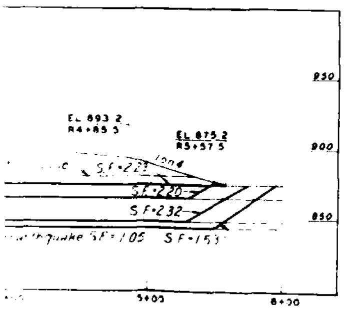
PARTIAL POOL CASE

STABILITY STUDIES USING RESIDUAL STRENGTHS FOR FOUNDATION OVERBURDEN AND SHALES	
CASE	SAFETY FACTOR
Steady Seepage	1.05
Partial Pool	1.16
Rapid Drawdown from Spillway Crest	1.02
Rapid Drawdown from Maximum Surcharge	0.98



RAPID DRAWDOWN		
EL. OF FAILURE PLANE	SAFETY FACTOR	
	FROM SPILLWAY CREST	FROM MAXIMUM SURCHARGE
875	131	123
865	141	134
849	154	1.46
844	1.40	136

PHYSICAL SOIL CONSTANTS								
MATERIAL	UNIT WEIGHT P/C.F.		DESIGN SHEAR STRENGTHS					
			"Q"		"R"		"S"	
	SAT.	DRAINED	C (TSF)	TAN Ø	C (TSF)	TAN Ø	C (TSF)	TAN Ø
Compacted Embankment	125	120	0.70	0.00	0.20	0.18	0.00	0.45
Berm Fill	115	110	0.70 / 0.40	0.10 / 0.00	0.10	0.20	0.00	0.35
Fdn. Fat Clays	115	110	0.20 / 0.80	0.20 / 0.00	0.30	0.20	0.00	0.35
Fdn. Lean Clays	115	110	0.20 / 0.80	0.20 / 0.00	0.30	0.20	0.00	0.45
Drum Limestone	165	—	—	—	—	—	0.00	0.70
Quivira Underclay	140	—	—	—	—	—	0.00	0.21



SAFETY FACTORS		
CASE	REQUIRED	ACTUAL
End of Construction	14	182
Rapid Drawdown From Spillway Crest	12	131
Rapid Drawdown From Maximum Surcharge	10	123
Partial Pool	15	158
Steady Seepage	15	153
Earthquake	10	1.05 *

*For Steady Seepage Case

SYM	DESCRIPTION	DATE	APP'D

REVISIONS

OSAGE RIVER BASIN

HILLSDALE LAKE

BIG BULL CREEK

EMBANKMENT STABILITY ANALYSIS SUMMARY
MAIN VALLEY STA 90+00

In 5 sheets — Sheet No 2 — Scale as shown

CORPS OF ENGINEERS, KANSAS CITY DISTRICT — U.S. ARMY, MARCH 1971

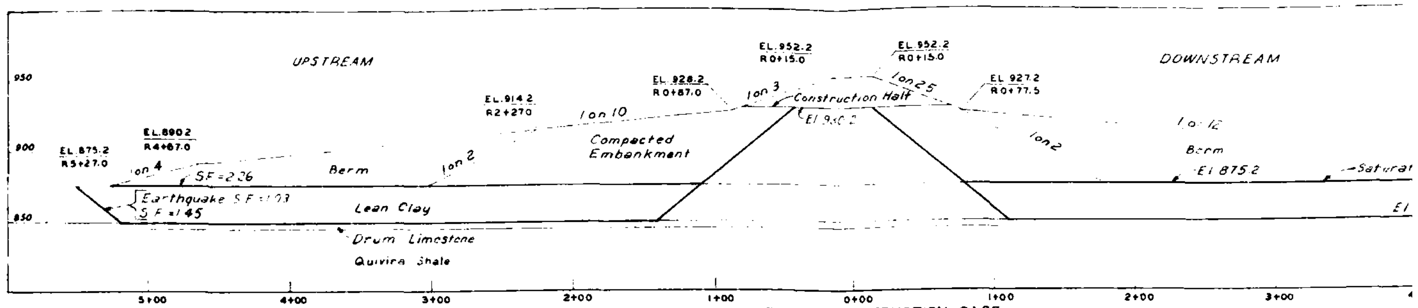
Submitted: Chief, Dams & Foundations Sect. — Recommended: Chief, Foundations & Mat'ls Br. — Approved: Chief, Engineering Division

Compiled by R.K.B.-W.G.A. — Drawn by P.W.M. — Checked by R.F.D.

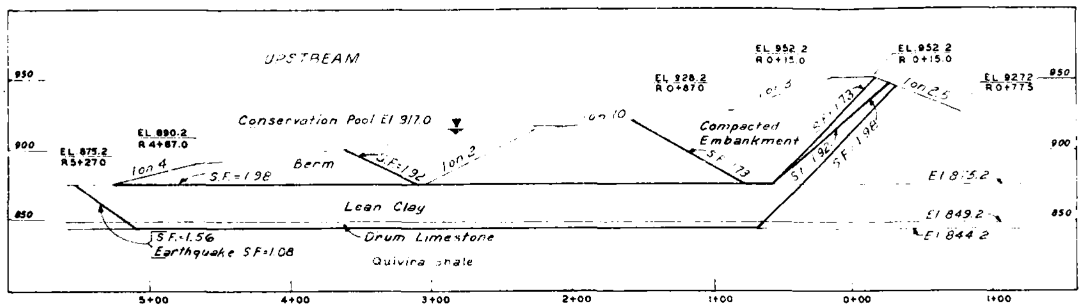
DM-7

File No. 0-15-248

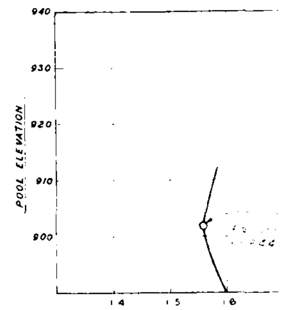
PLATE NO 60

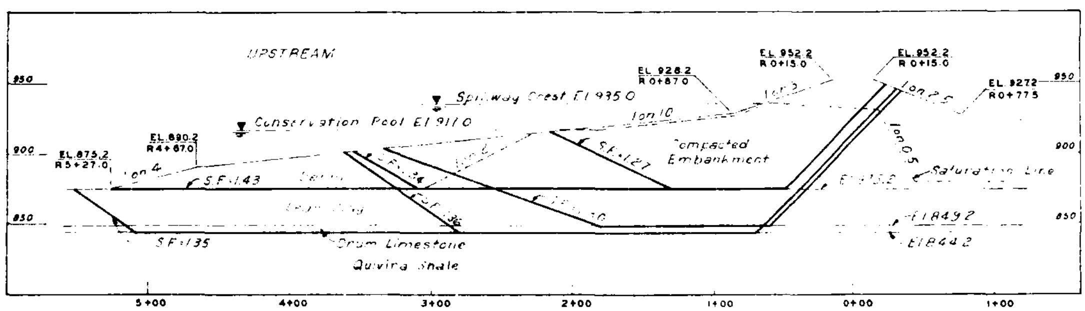


END OF CONSTRUCTION CASE



PARTIAL POOL CASE

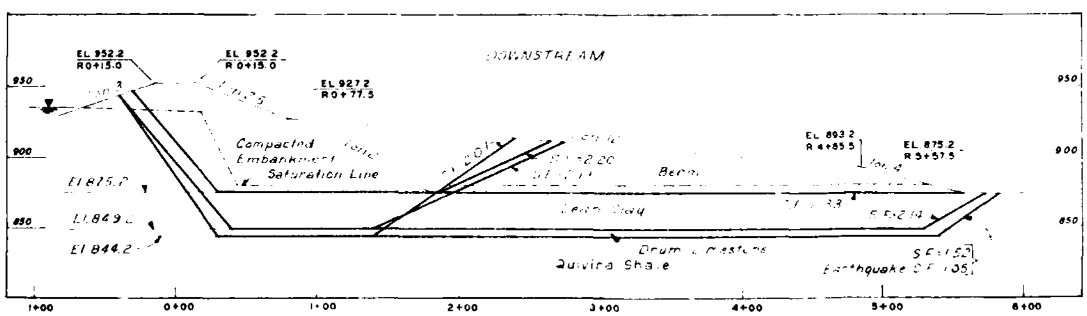




RAPID DRAWDOWN CASE (FROM SPILLWAY CREST)

RAPID DRAWDOWN

EL OF FAILURE PLANE	SAFETY FACTOR FROM SPILLWAY CREST	SAFETY FACTOR FROM MAXIMUM SURCHARGE
875	[illegible]	[illegible]
849	1.30	[illegible]
844	[illegible]	[illegible]

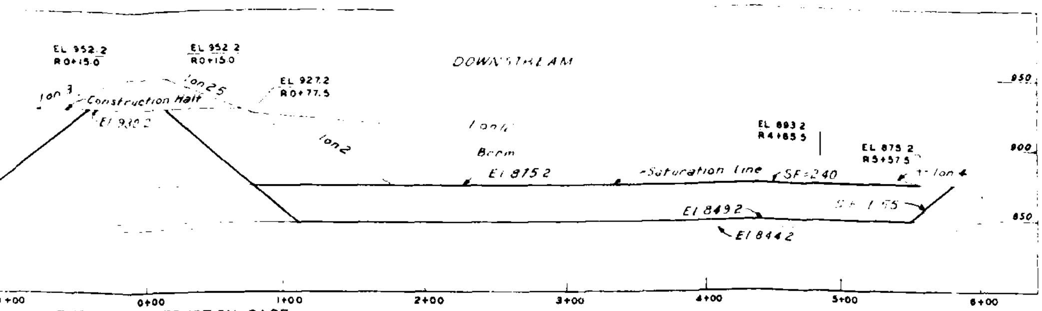


STEADY SEEPAGE CASE

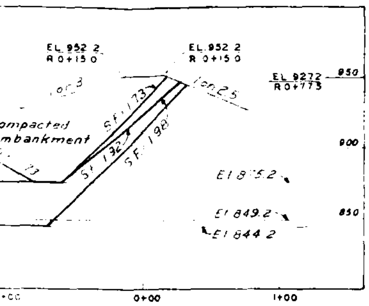
SAFETY FA[CTORS]

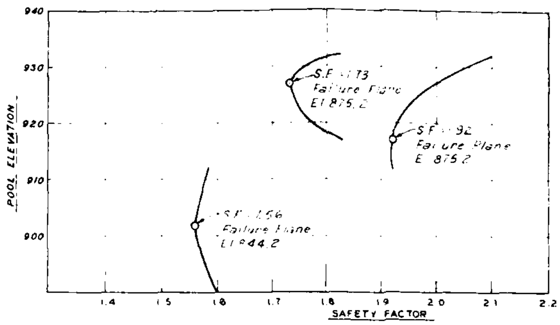
CASE
Construction Halt El 9[illegible]
Rapid Drawdown From Spillway Crest
Rapid Drawdown From Maximum Surcharge
Partial Pool
Steady Seepage
Earthquake

*For Steady Seepage Case [illegible]

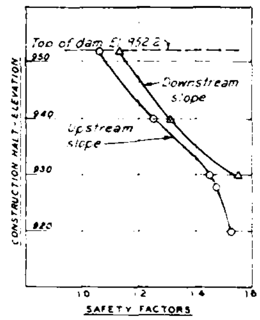


END OF CONSTRUCTION CASE

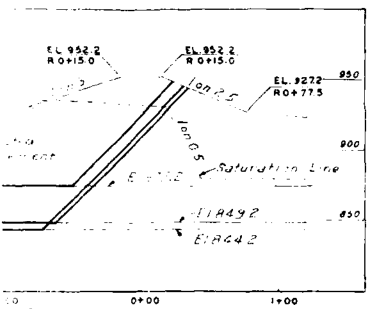




PARTIAL POOL CASE



CONSTRUCTION CASE

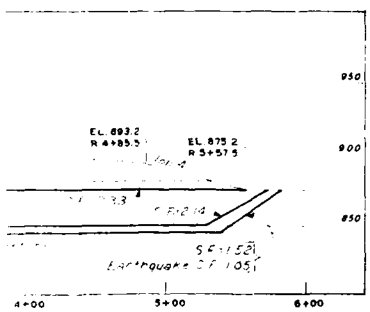


ST)

RAPID DRAWDOWN		
EL OF FAILURE PLANE	SAFETY FACTOR FROM SPILLWAY CREST	SAFETY FACTOR FROM MAXIMUM SURCHARGE
875	1.27	1.20
849	1.30	
844	1.56	1.32

PHYSICAL SOIL CONSTANTS								
MATERIAL	UNIT WEIGHT P.C.F. SAT	UNIT WEIGHT P.C.F. DRAINED	DESIGN SHEAR STRENGTHS C (TSF)	TAN ø	C (TSF)	TAN ø	C (TSF)	TAN ø
Compacted embankment	25	[illegible]	[illegible]	[illegible]	[illegible]	180	[illegible]	450
Berm fill	[illegible]		[illegible]	.00	[illegible]	[illegible]	[illegible]	350
Little Bull Fan Clays	[illegible]	[illegible]	400	.000		.200		[illegible]
[illegible]	[illegible]							[illegible]
Quarry Undercl ay	49						[illegible]	[illegible]

STABILITY STUDIES USING RESIDUAL STRENGTHS FOR FOUNDATION OVERBURDEN AND SHALES	
CASE	SAFETY FACTOR
Steady seepage	1.05
Partial pool	[illegible]5
Rapid drawdown from spillway crest	[illegible]
Rapid drawdown from maximum surcharge	2.97



SAFETY FACTORS		
CASE	REQUIRED	ACTUAL
Construction Halt El 930.2	[illegible]	1.45
Rapid Drawdown From Spillway Crest	[illegible]	1.27
Rapid Drawdown From Maximum Surcharge	[illegible]	1.20
Partial Pool	[illegible]	1.56
Steady Seepage	[illegible]	1.52
Earthquake	[illegible]	[illegible] *

* For Steady Seepage Case

SYM | DESCRIPTION | DATE | APP'D

REVISIONS

OSAGE RIVER BASIN

HILLSDALE LAKE

BIG BULL CREEK

EMBANKMENT STABILITY ANALYSIS SUMMARY
LITTLE BULL AREA - STA 104+00

In 5 sheets | Sheet No. 3 | Scale as shown

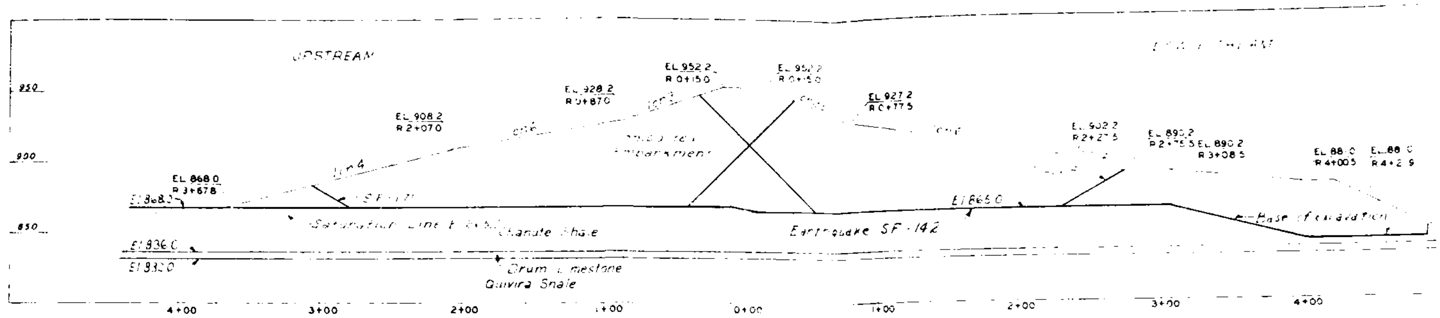
CORPS OF ENGINEERS
KANSAS CITY DISTRICT

U.S. ARMY
MARCH 1971

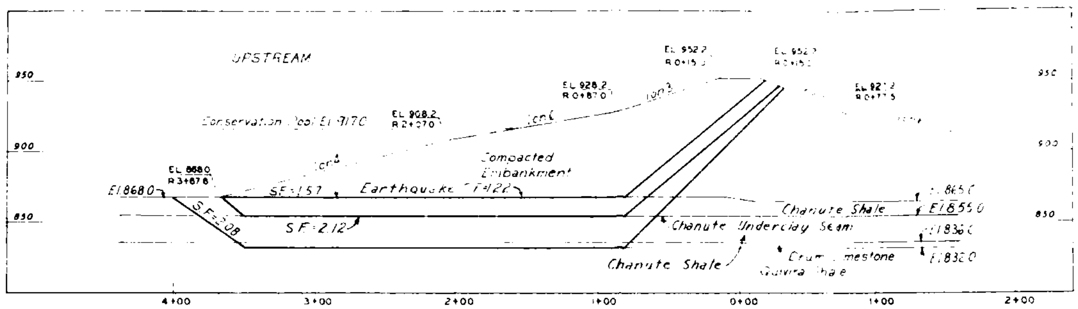
Submitted | Recommended | Approved

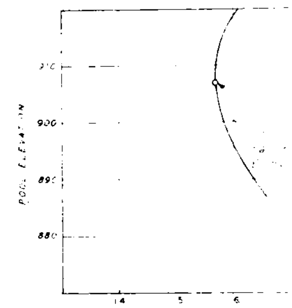
RKB-WGA JAM | RFD | DM-7 | 0-15-249

PLATE NO 61

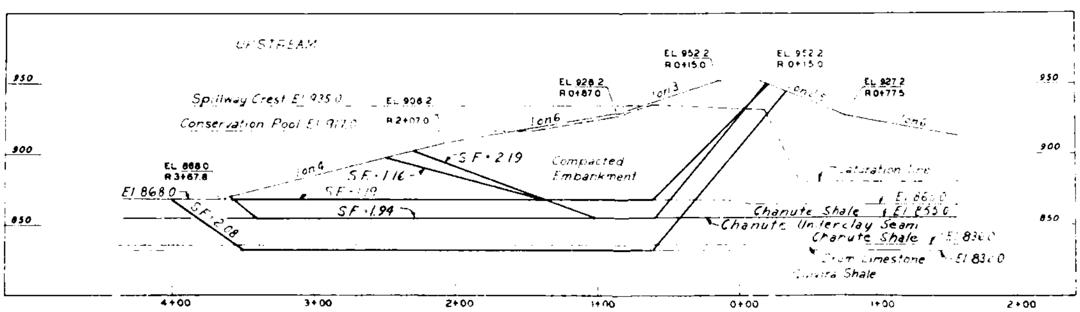


END OF CONSTRUCTION CASE





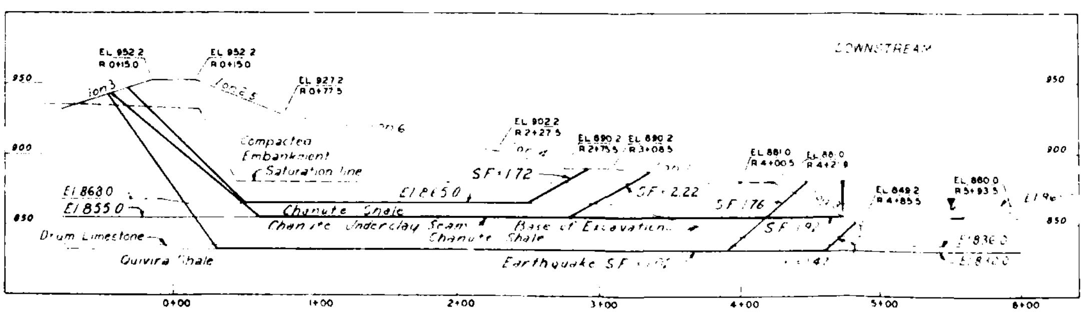
PAR



RAPID DRAWDOWN CASE (FROM SPILLWAY CREST)

RAPID DRAWDOWN

EL. OF FAILURE PLANE	SAFETY FACTOR FROM SPILLWAY CREST	SAFETY FACTOR FROM MAXIMUM SURCHARGE
868	[illegible]	[illegible]
855	1.94	1.89
832	2.08	[illegible]

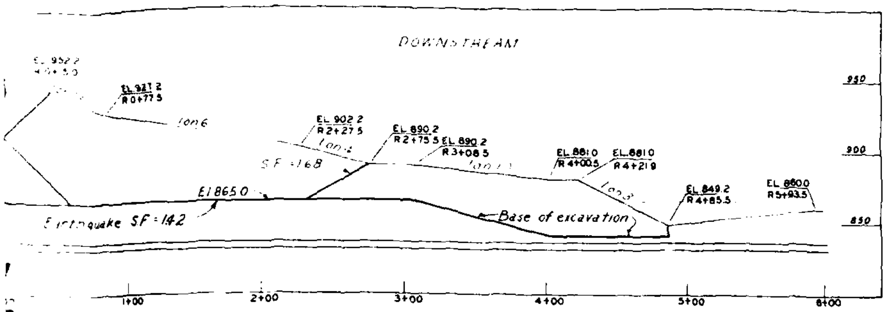


STEADY SEEPAGE CASE

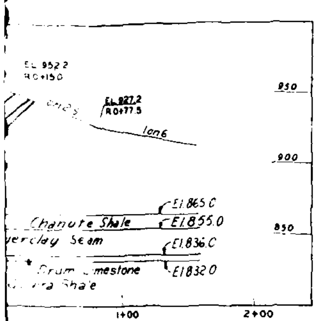
SAFETY FACTORS

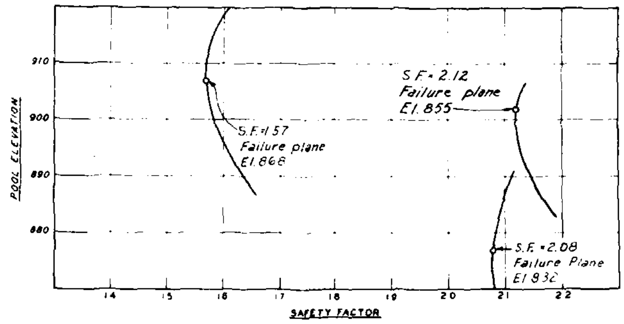
CASE
End of construction
Rapid drawdown from spillway crest
Rapid drawdown from maximum surcharge
Partial pool
Steady seepage
Earthquake

* For steady seepage case



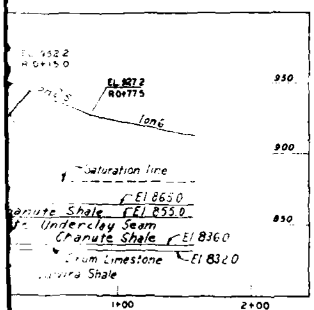
OF CONSTRUCTION CASE





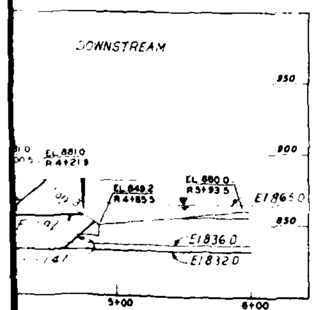
PARTIAL POOL CASE

STABILITY STUDIES USING RESIDUAL STRENGTHS FOR FOUNDATION OVERBURDEN AND SHALES		
CASE	SAFETY FACTOR	
	832 PLANE	855 PLANE
Steady Seepage	0.82-1.05	1.15
Partial Pool	1.12	1.09
Rapid Drawdown from Spillway Crest	1.00	0.92
Rapid Drawdown From Max. Surcharge	0.92	0.89



RAPID DRAWDOWN		
EL. OF FAILURE PLANE	SAFETY FACTOR	
	FROM SPILLWAY CREST	FROM MAXIMUM SURCHARGE
868	1.16	1.11
855	1.94	1.89
832	2.08	2.03

PHYSICAL SOIL CONSTANTS									
MATERIAL	UNIT WEIGHT P.C.F.		DESIGN SHEAR STRENGTH						
			"Q"		"R"		"S"		
	SAT	DRAINED	C (TSF)	TAN Ø	C (TSF)	TAN Ø	C (TSF)	TAN Ø
Compacted embankment	125	120	0.70	0.00	0.20	0.18	0.00	0.45
Embankment-Shale Contact Plane	—	—	0.70	0.00	0.20	0.18	0.00	0.45
Chanute Shale Cross Bed	135	130	—	—	—	—	1.50	0.40
Chanute Underclay Seam	—	—	—	—	—	—	0.00	0.40
Drum Limestone	165	—	—	—	—	—	1.50	0.50
Quivira Underclay	140	—	—	—	—	—	0.00	0.21



SAFETY FACTORS		
CASE	REQUIRED	ACTUAL
End of construction	1.4	1.68
Rapid drawdown from spillway crest	1.2	1.16
Rapid drawdown from maximum surcharge	1.0	1.11
Partial pool	1.5	1.57
Steady seepage	1.5	1.47-1.72
Earthquake	1.0	1.02*

*For steady seepage case

SYM	DESCRIPTION	DATE	APP'D

REVISIONS

OSAGE RIVER BASIN

HILLSDALE LAKE

BIG BULL CREEK

EMBANKMENT STABILITY ANALYSIS SUMMARY
OUTLET WORKS-STA. 112+86

In 5 sheets
Sheet No. 4
Scale: as shown

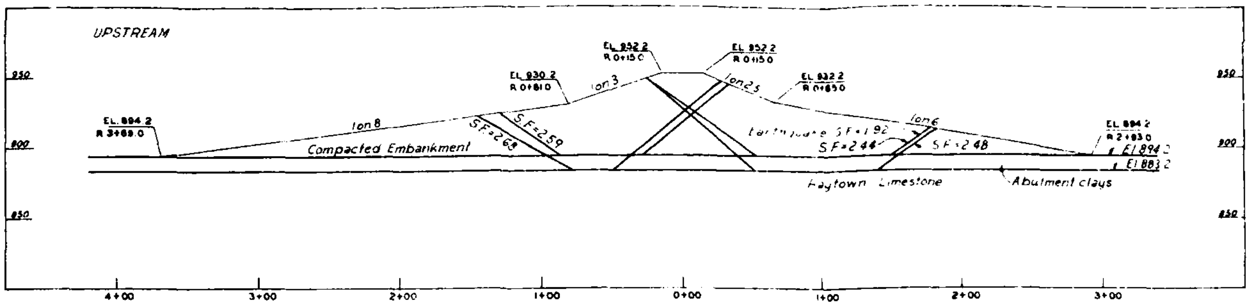
CORPS OF ENGINEERS
KANSAS CITY DISTRICT

U. S. ARMY
MARCH 1971

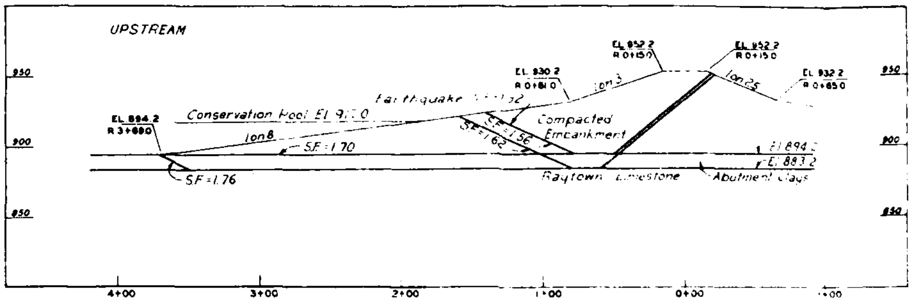
Submitted
CHIEF, DAMS & FOUNDATIONS SECT.
Recommended
CHIEF, FOUNDATIONS & MATLS. BR.
Approved
CHIEF, ENGINEERING DIVISION

COMPILED BY RKB-WGA
DRAWN BY CHL
CHECKED BY RFC
DM
FILE NO. O-15-230

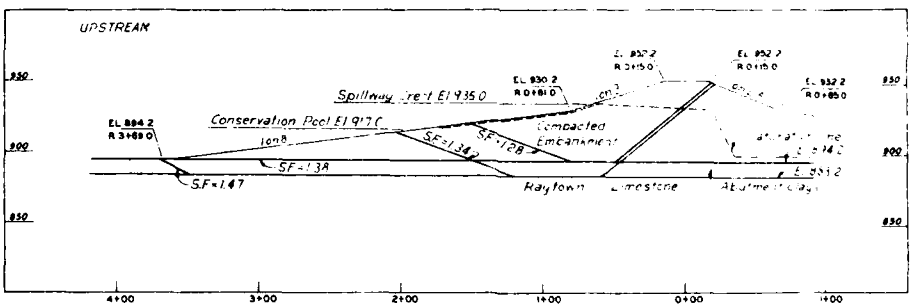
PLATE NO. 6.



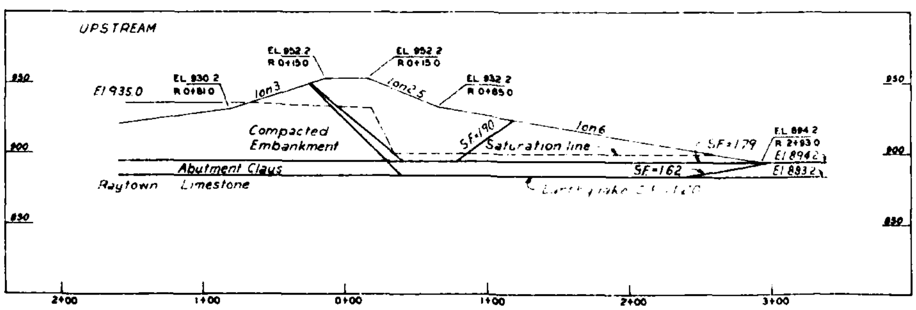
END OF CONSTRUCTION CASE



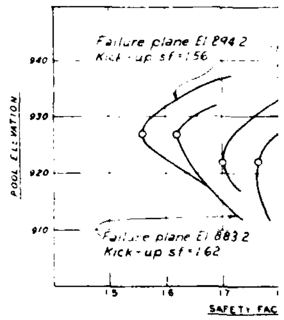
PARTIAL POOL CASE



RAPID DRAWDOWN CASE (FROM SPILLWAY CREST)



STEADY SEEPAGE CASE

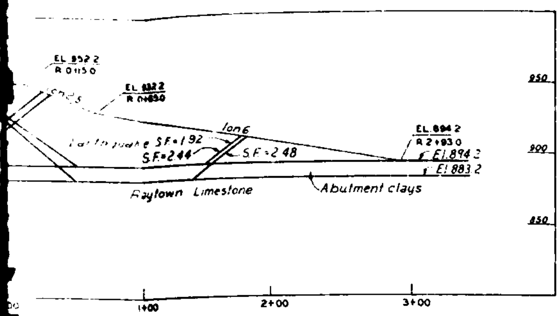


PARTIAL POO

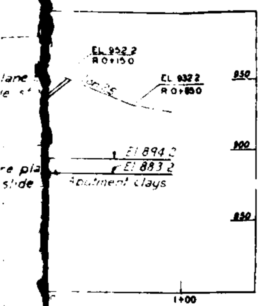
RAPID DRAWDOWN		
	SAFETY FACTOR	
EL. OF FAILURE PLANE	FROM SPILLWAY CREST	FROM MAXIMUM SURCHARGE
894.2	1.28	1.18
883.2	1.34	1.26

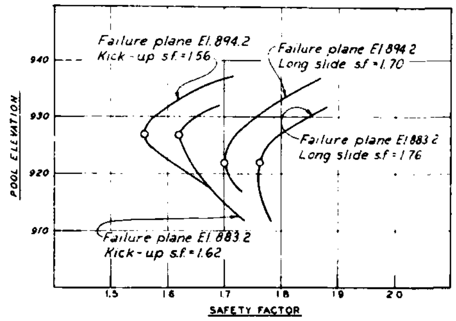
SAFETY FA
CASE
End of construction
Rapid drawdown from spillway crest
Rapid drawdown from maximum surcharge
Partial pool
Steady seepage
Earthquake

* For Steady Seepage Cas



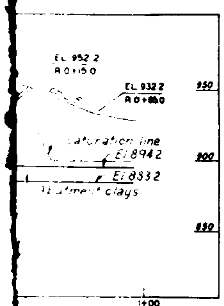
CASE





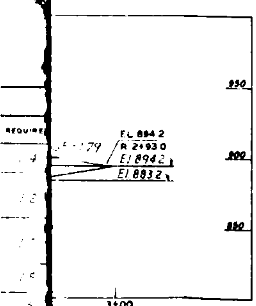
PARTIAL POOL CASE

STABILITY STUDIES USING RESIDUAL STRENGTHS FOR FOUNDATION OVERBURDEN AND SHALES	
CASE	SAFETY FACTOR
Steady seepage	1.27
Partial pool	1.37
Rapid drawdown from spillway crest	1.10
Rapid drawdown from max. surcharge	1.03



RAPID DRAWDOWN		
	SAFETY FACTOR	
EL. OF FAILURE PLANE	FROM SPILLWAY CREST	FROM MAXIMUM SURCHARGE
894.2	1.28	1.18
883.2	1.34	1.26

PHYSICAL SOIL CONSTANTS									
MATERIAL	UNIT WEIGHT P.C.F.		DESIGN SHEAR STRENGTH						
			"Q"		"R"		"S"		
	SAT	DRAINED	C (TSF)	TAN Ø	C (TSF)	TAN Ø	C (TSF)	TAN Ø
Compacted embankment	125	120	.700	.000	.200	.180	.000	.450
Abutment clays	120	115	.900	.000	.300	.200	.000	.350
Raytown Ls	165	—	—	—	—	—	.000	.700



SAFETY FACTORS		
CASE	REQUIRED	ACTUAL
End of construction	1.4	2.44
Rapid drawdown from spillway crest	1.2	1.28
Rapid drawdown from maximum surcharge	1.0	1.18
Partial pool	1.5	1.54
Steady seepage	1.5	1.62
Earthquake	1.0	1.20 *

* For Steady Seepage Case

SYM DESCRIPTION DATE APP'D.
REVISIONS

OSAGE RIVER BASIN

HILLSDALE LAKE

BIG BULL CREEK

EMBANKMENT STABILITY ANALYSIS SUMMARY
LEFT ABUTMENT- STA. 115+00

In 5 sheets — Sheet No. 5 — Scale: as shown

CORPS OF ENGINEERS
KANSAS CITY DISTRICT

U. S. ARMY
MARCH 1971

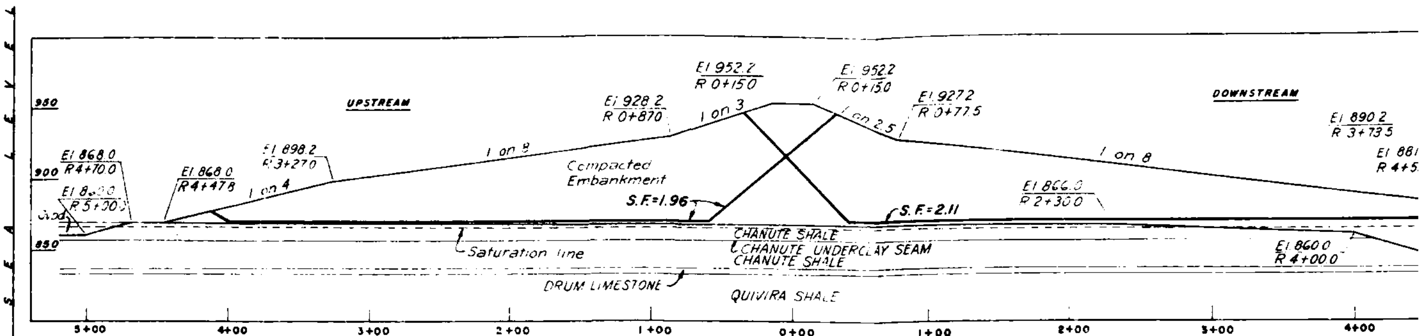
Submitted — Recommended — Approved

CHIEF, DAMS & FOUNDATIONS SECT. — CHIEF, FOUNDATIONS & MATLS. BR. — CHIEF, ENGINEERING DIVISION

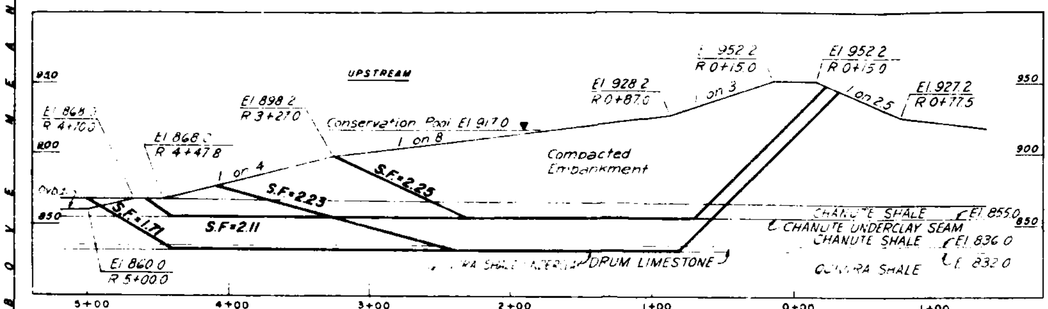
COMPILED BY R.K.B.-W.G.A. — DRAWN BY C.H.L. — CHECKED BY R.F.D. — DM-

FILE NO. 0-15-251

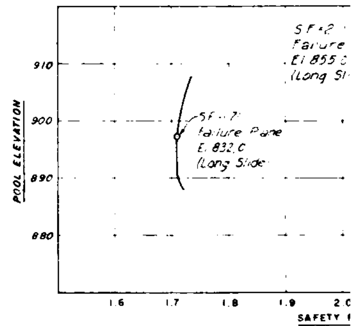
PLATE NO 63



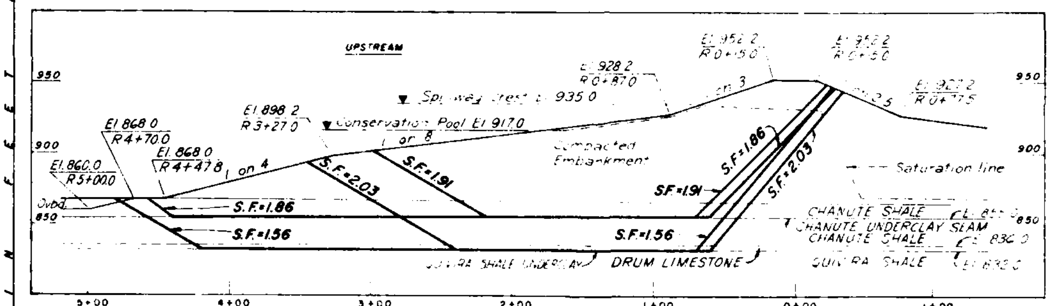
END OF CONSTRUCTION CASE



PARTIAL POOL CASE

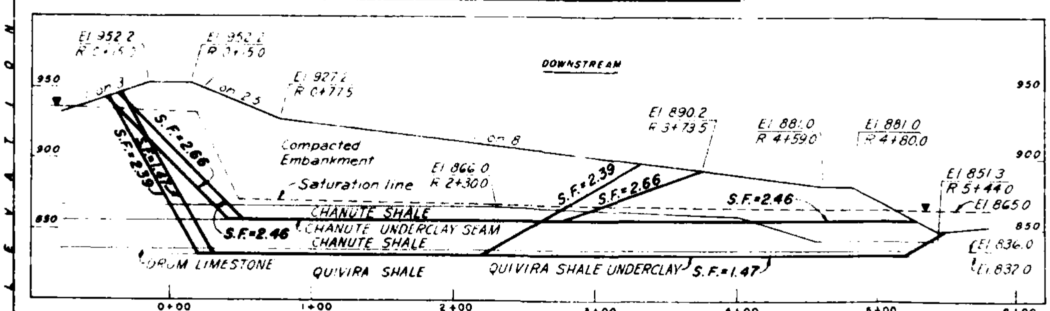


PARTIAL PO



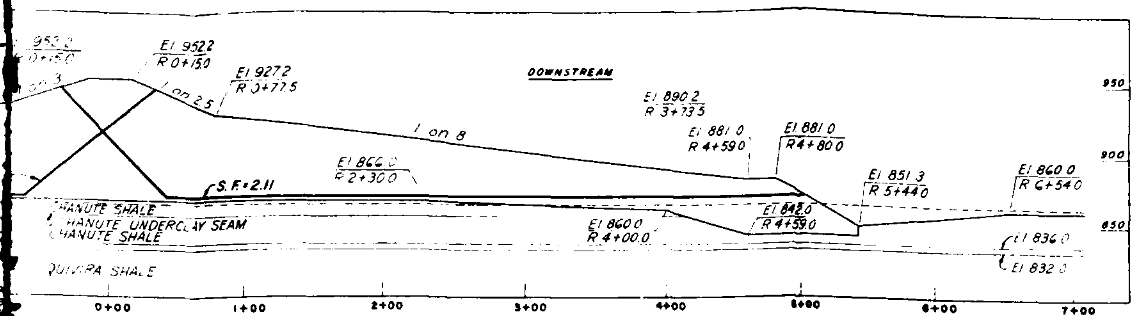
RAPID DRAWDOWN CASE (FROM SPILLWAY CREST)

RAPID DRAWDOWN		
EL. OF FAILURE PLANE	SAFETY FACTOR FROM SPILLWAY CREST	SAFETY FACTOR FROM MAXIMUM SURCHARGE
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]

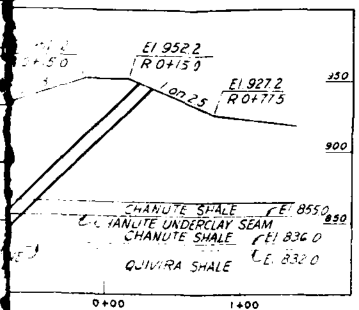


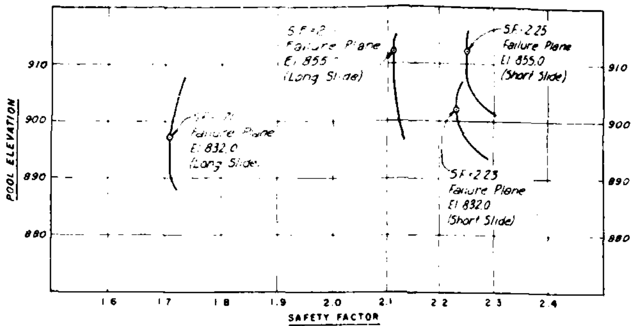
STEADY SEEPAGE CASE

REQUIRED SAFETY FACTORS
CASE
END OF CONSTRUCTION
RAPID DRAWDOWN FROM SPILLWAY CREST
RAPID DRAWDOWN FROM MAXIMUM SURCHARGE
PARTIAL POOL
STEADY SEEPAGE
EARTHQUAKE



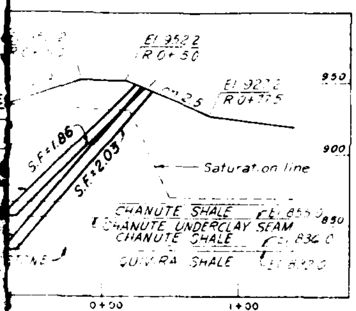
END OF CONSTRUCTION CASE





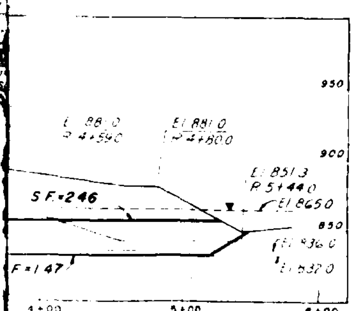
PARTIAL POOL CASE

CASE AND FAILURE PLANE	SAFETY FACTOR	
	PEAK STRENGTHS	RESIDUAL STRENGTHS
PARTIAL POOL failure plane along Chanute underclay	[illegible]	0.99
PARTIAL POOL failure plane along Quivira underclay	1.71	1.17
STEADY SEEPAGE failure plane along Chanute underclay	2.46	1.11
STEADY SEEPAGE failure plane along Quivira underclay	1.47	0.95



RAPID DRAWDOWN		
EL. OF FAILURE PLANE	SAFETY FACTOR	
	FROM SPILLWAY CREST	FROM MAXIMUM SURCHARGE
855	[illegible]	[illegible]
832	1.5[illegible]	1.[illegible]

PHYSICAL SOIL CONSTANTS								
MATERIAL	UNIT WEIGHT P/C F		DESIGN SHEAR STRENGTHS					
			Q		R		S	
	SAT	DRAINED	C (TSF)	TAN Ø	C (TSF)	TAN Ø	C (TSF)	TAN Ø
Compacted Embankment	[illegible]	[illegible]				[illegible]	[illegible]	[illegible]45
Overburden	[illegible]5	[illegible]	[illegible]	[illegible]				[illegible]
Chanute Shale Cross Bed (Peak)	[illegible]	[illegible]					[illegible]	[illegible]
Chanute Shale Cross Bed (Residual)	135	[illegible]					[illegible]	[illegible]3[illegible]
Chanute Underclay Seam (Peak)	—				[illegible]	[illegible]	0.00	0.40
Chanute Underclay Seam (Residual)	—						[illegible]	[illegible]
[illegible]	[illegible]	165					[illegible]	[illegible]
Quivira Underclay (Peak)	140	140					0.00	0.21
Quivira Underclay (Residual)	140	140					0.00	0.13



REQUIRED SAFETY FACTORS	
CASE	SAFETY FACTOR
END OF CONSTRUCTION	1.4
RAPID DRAWDOWN FROM SPILLWAY CREST	1.2
RAPID DRAWDOWN FROM MAXIMUM SURCHARGE	1.0
PARTIAL POOL	1.5
STEADY SEEPAGE	1.5
EARTHQUAKE	1.0

SYM DESCRIPTION DATE APP'D
REVISIONS

BIG BULL CREEK KANSAS

HILLSDALE LAKE

EMBANKMENT STABILITY ANALYSIS SUMMARY OUTLET WORKS

In 1 sheet · Sheet No. 1 · Scale as shown

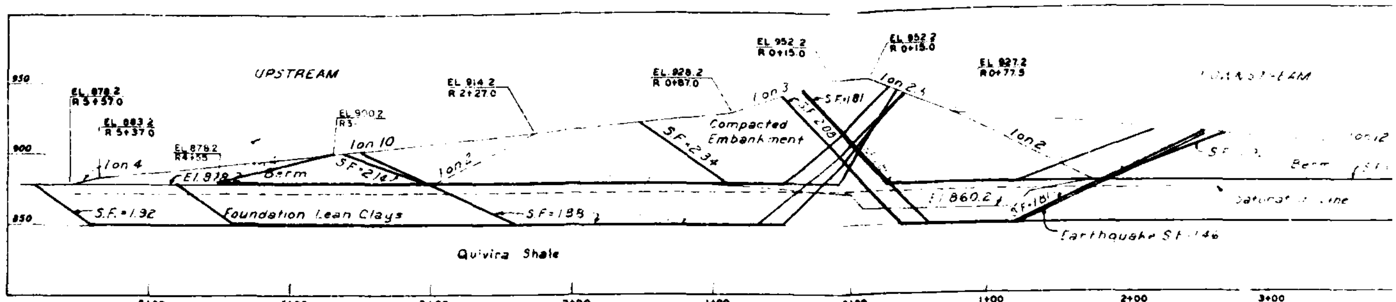
CORPS OF ENGINEERS KANSAS CITY DISTRICT · U.S. ARMY · DECEMBER 1971

Submitted · Recommended · Approved

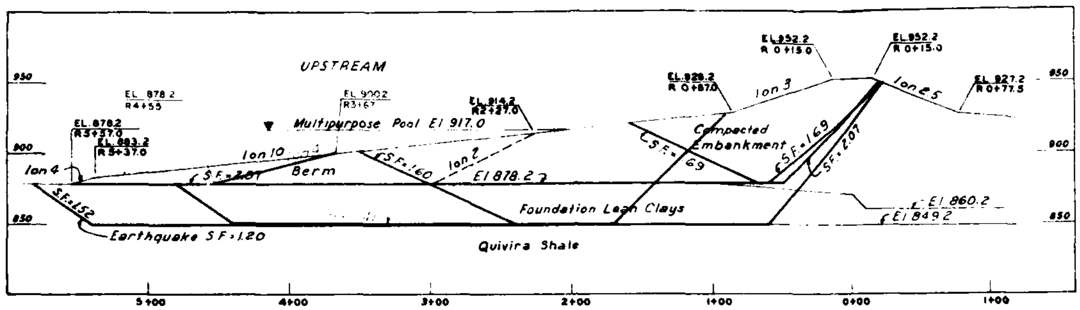
CHIEF DAMS & FOUNDATIONS SECT. · CHIEF FOUNDATIONS & MATLS BR. · CHIEF ENGINEERING DIVISION

COMPILED BY W.B.A. · DRAWN BY F.C.L. · CHECKED BY R.F.R. · DM-7 · FILE NO. 0-15-300

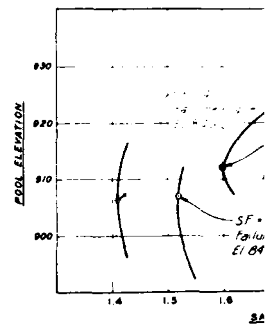
PLATE NO. 64

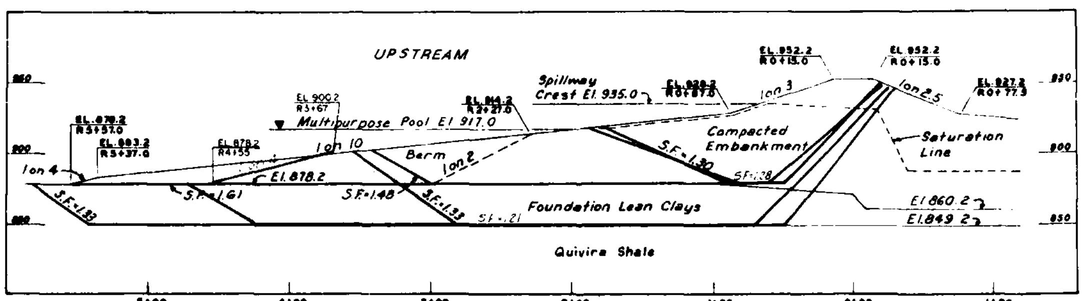


END OF CONSTRUCTION CASE

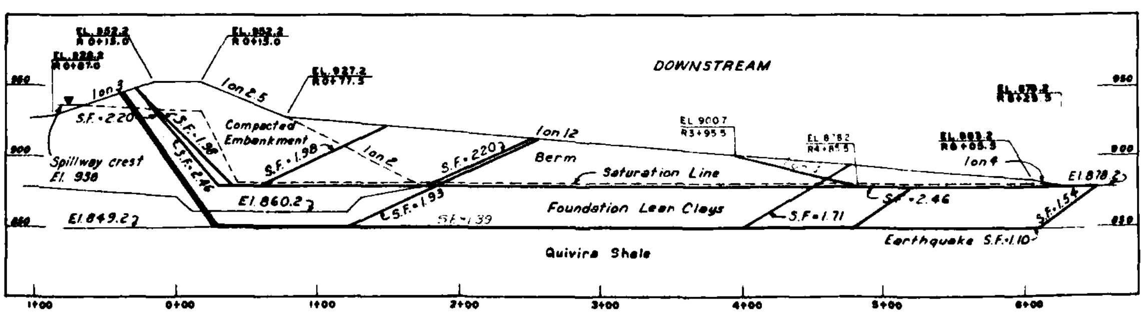


PARTIAL POOL CASE





RAPID DRAWDOWN CASE (FROM SPILLWAY CREST)

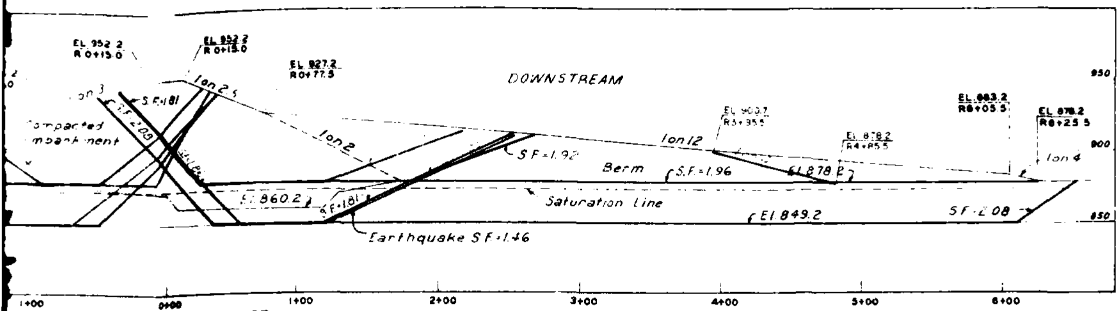


STEADY SEEPAGE CASE

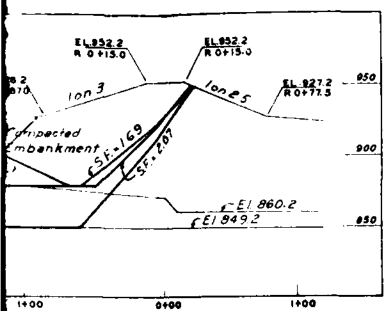
RAPID DRAWDOWN		
EL OF FAILURE PLANE	SAFETY FACTOR FROM SPILLWAY CREST	FROM MAXIMUM SURCHARGE
878	1.30	1.21
849	1.33	1.28
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]

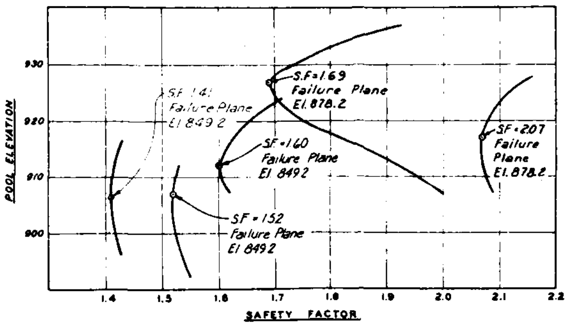
SAFETY FAC
CASE
End of Construction
Rapid Drawdown From Spillway Crest
Rapid Drawdown From Maximum surcharg
Partial Pool
Steady Seepage
Earthquake

* For Steady Seepage Case



END OF CONSTRUCTION CASE

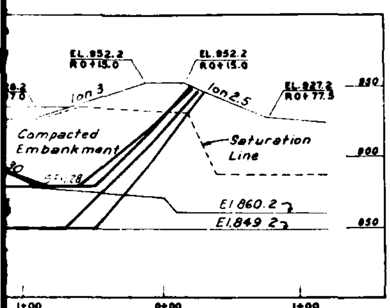




PARTIAL POOL CASE

RAPID DRAWDOWN		
EL. OF FAILURE PLANE	SAFETY FACTOR	
	FROM SPILLWAY CREST	FROM MAXIMUM SURCHARGE
878	1.30	1.21
849	1.33	1.28
878	1.28	1.22
849	[illegible]	[illegible]

PHYSICAL SOIL CONSTANTS									
MATERIAL	UNIT WEIGHT P/CF		DESIGN SHEAR STRENGTHS						
			"Q"		"R"		"S"		
	SAT.	DRAINED	C (TSF)	TAN Φ	C (TSF)	TAN Φ	C (TSF)	TAN Φ	
Compacted Embankment	125	120	700	.000	200	180	000	.450	
Berm Fill	115	110	100 / .400	.100 / .000	100	200	.000	.350	
Fdn Lean Clays	115	110	.200 / .800	200 / .000	.300	.200	.000	.450	
Quivira Underclay (Peak)	140	—	—	—	—	—	.000	.210	
Quivira Underclay (Residual)	140	—	—	—	—	—	.000	.130	



REST)

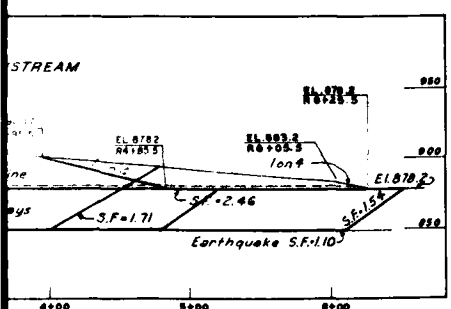
SAFETY FACTORS			
CASE	REQUIRED	ACTUAL	REVISED SECTION
End of Construction	1.4	1.81	
Rapid Drawdown From Spillway Crest	1.2	1.30	
Rapid Drawdown From Maximum surcharge	1.0	1.21	
Partial Pool	1.5	1.52	
Steady Seepage	1.5	1.54	
Earthquake	1.0	1.10 *	

* For Steady Seepage Case

STABILITY STUDIES USING RESIDUAL STRENGTHS FOR FOUNDATION OVERBURDEN (1) AND SHALES

CASE	SAFETY FACTOR	REVISED SECTION (1)
Steady Seepage	1.06	
Partial Pool	1.09	
Rapid Drawdown From Spillway Crest	0.94	
Rapid Drawdown From Max Surcharge	0.90	

(1) RESIDUAL STRENGTHS WERE NOT USED FOR OVERBURDEN IN REVISED SECTION



SYM.	DESCRIPTION	DATE	APP'D.
	REVISIONS		

BIG BULL CREEK, KANSAS

HILLSDALE LAKE

EMBANKMENT STABILITY ANALYSIS SUMMARY STATION 81+00

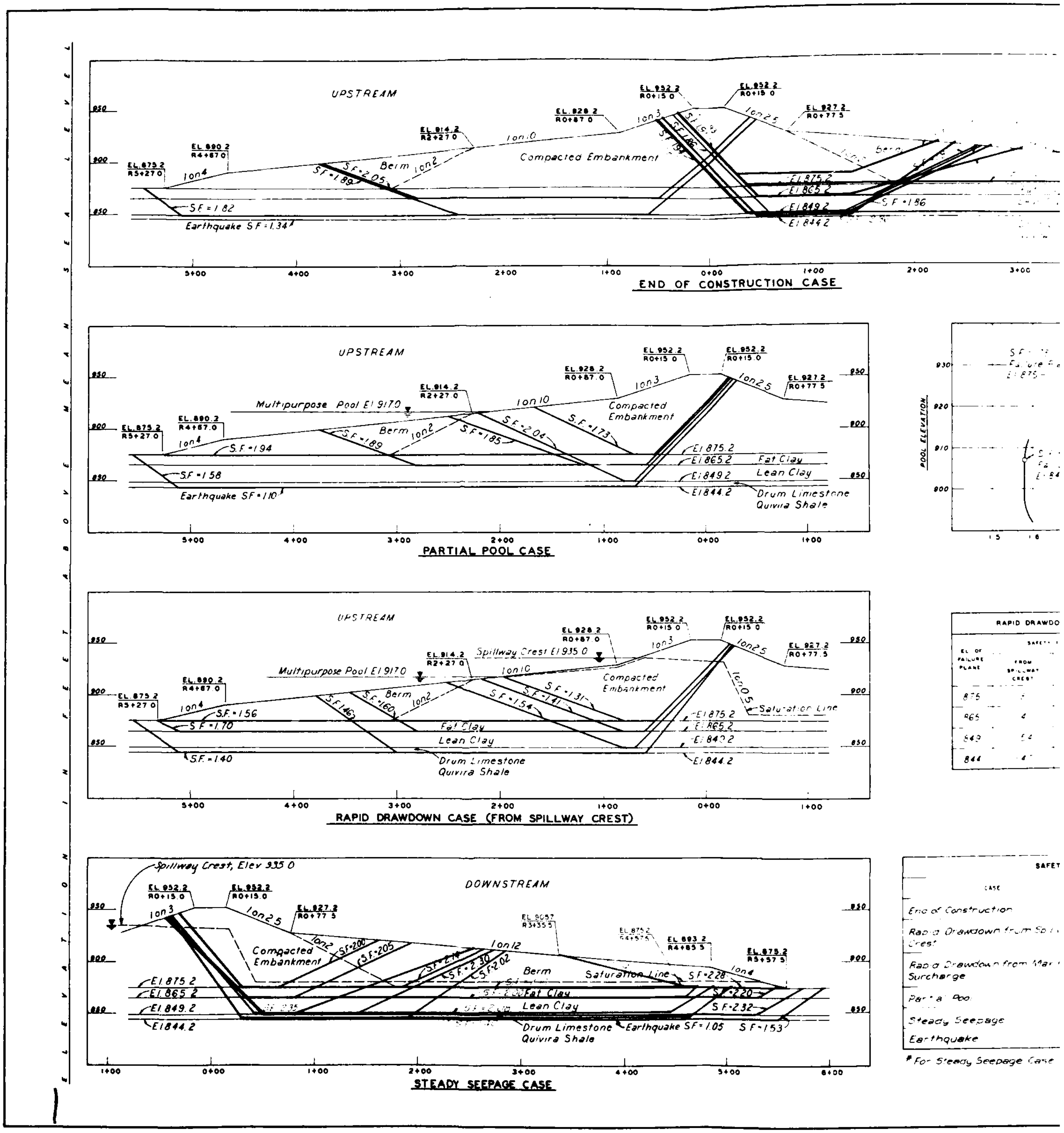
In 1 sheet — Sheet No. 1 — Scale: as shown

CORPS OF ENGINEERS KANSAS CITY DISTRICT — U. S. ARMY JANUARY 1978

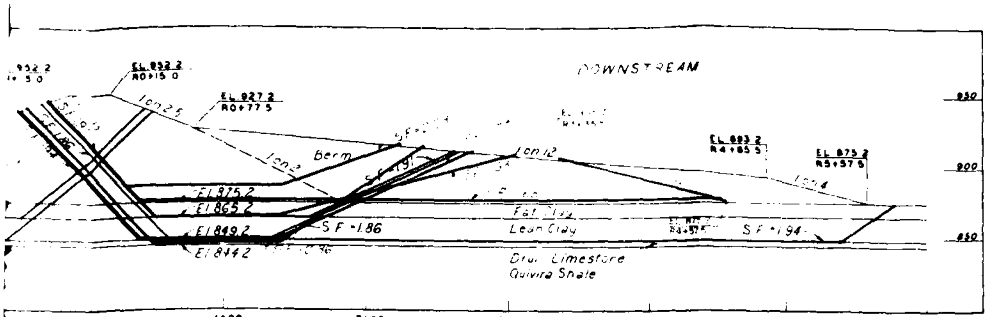
Submitted — Recommended — Approved

COMPILED BY G A D — DRAWN BY R L D. — CHECKED BY R G F. — DM-7 — FILE NO. 0-15-675

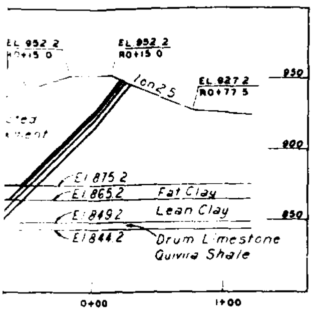
PLATE NO. 65

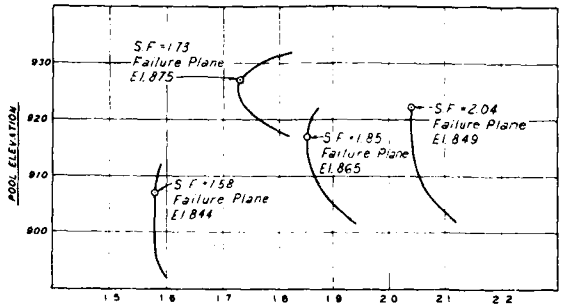


UPSTREAM
EL 952.2 R0+15.0
EL 928.2 R0+87.0
EL 914.2 R2+27.0
EL 890.2 R4+87.0
EL 875.2 R5+27.0
EL 927.2 R0+77.5
1 on 3
1 on 2.5
1 on 10
1 on 4
1 on 2
Berm
Compacted Embankment
S.F. = 2.05
S.F. = 1.89
S.F. = 1.82
S.F. = 1.86
Earthquake S.F. = 1.34*
El 875.2
El 865.2
El 849.2
El 844.2
END OF CONSTRUCTION CASE
UPSTREAM
Multipurpose Pool El 917.0
S.F. = 1.94
S.F. = 1.89
S.F. = 1.85
S.F. = 2.04
S.F. = 1.73
S.F. = 1.58
Earthquake S.F. = 1.10*
Fat Clay
Lean Clay
Drum Limestone
Quivira Shale
PARTIAL POOL CASE
UPSTREAM
Spillway Crest El 935.0
Multipurpose Pool El 917.0
1 on 0.5
Saturation Line
S.F. = 1.56
S.F. = 1.70
S.F. = 1.46
S.F. = 1.60
S.F. = 1.54
S.F. = 1.41
S.F. = 1.31
S.F. = 1.40
RAPID DRAWDOWN CASE (FROM SPILLWAY CREST)
Spillway Crest, Elev 935.0
DOWNSTREAM
EL 905.7 R3+35.5
EL 893.2 R4+85.5
EL 875.2 R5+57.5
1 on 12
S.F. = 2.00
S.F. = 2.05
S.F. = 2.30
S.F. = 2.02
S.F. = 2.28
S.F. = 2.20
S.F. = 2.32
Earthquake S.F. = 1.05
S.F. = 1.53
STEADY SEEPAGE CASE
POOL ELEVATION
RAPID DRAWDO
SAFET
CASE
End of Construction
Rapid Drawdown from Spillway Crest
Rapid Drawdown from Max Surcharge
Partial Pool
Steady Seepage
Earthquake
* For Steady Seepage Case



ND OF CONSTRUCTION CASE

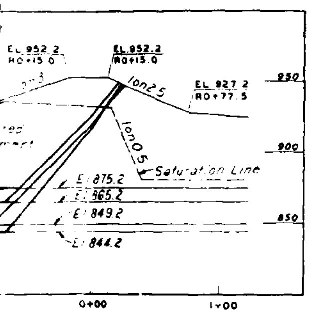




PARTIAL POOL CASE

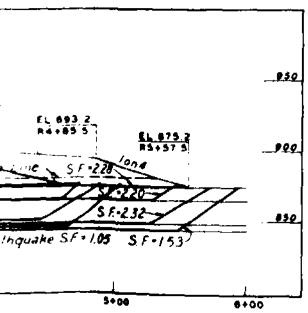
STABILITY STUDIES USING RESIDUAL STRENGTHS FOR FOUNDATION OVERBURDEN (1) AND SHALES	
CASE	SAFETY FACTOR
Steady Seepage	1.05 (2)
Partial Pool	1.16
Rapid Drawdown from Spillway Crest	1.02
Rapid Drawdown from Maximum Surcharge	0.98

(1) RESIDUAL STRENGTHS WERE NOT USED FOR OVERBURDEN IN REVISED SECTION
(2) FOR REVISED SECTION, WHICH IS SAME AS STA. 104+00, THE S.F = 1.02



RAPID DRAWDOWN		
EL. OF FAILURE PLANE	SAFETY FACTOR FROM SPILLWAY CREST	SAFETY FACTOR FROM MAXIMUM SURCHARGE
875	1.31	1.23
865	1.41	1.34
849	1.54	1.48
844	1.40	1.36

PHYSICAL SOIL CONSTANTS								
MATERIAL	UNIT WEIGHT P/C.F		DESIGN SHEAR STRENGTHS					
			Q		R		S	
	SAT.	DRAINED	C (TSF)	TAN Ø	C (TSF)	TAN Ø	C (TSF)	TAN Ø
Compacted Embankment	125	120	0.70	0.00	0.20	0.18	0.00	0.45
Berm Fill	115	110	0.10 / 0.40	0.10 / 0.00	0.10	0.20	0.00	0.35
Fdn. Fat Clays	115	110	0.20 / 0.80	0.20 / 0.00	0.30	0.20	0.00	0.35
Fdn Lean Clays	115	110	0.20 / 0.80	0.20 / 0.00	0.30	0.20	0.00	0.45
Drum Limestone	165	—	—	—	—	—	0.00	0.70
Quivira Underclay (Peak)	140	—	—	—	—	—	0.00	0.21
Quivira Underclay (Residual)	140	—	—	—	—	—	0.00	0.13



SAFETY FACTORS			
CASE	REQUIRED	ACTUAL	REVISED SECTION
End of Construction	1.4	1.82	1.65
Rapid Drawdown from Spillway Crest	1.2	1.31	
Rapid Drawdown from Maximum Surcharge	1.0	1.23	
Partial Pool	1.5	1.58	
Steady Seepage	1.5	1.53	
Earthquake	1.0	1.05 *	

* For Steady Seepage Case

SYM.	DESCRIPTION	DATE	APP'D

REVISIONS

BIG BULL CREEK, KANSAS

HILLSDALE LAKE

EMBANKMENT STABILITY ANALYSIS SUMMARY
STATION 90+00

In 1 sheet — Sheet No. 1 — Scale: as shown

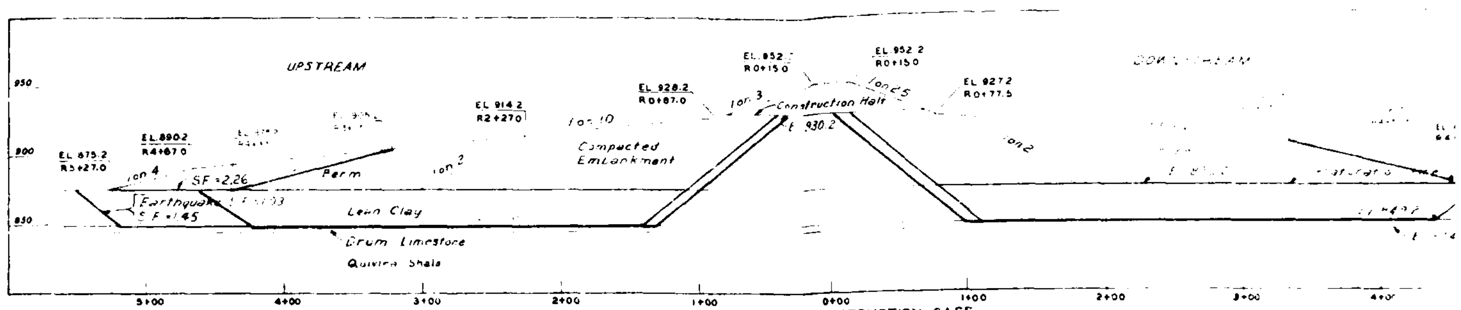
CORPS OF ENGINEERS, KANSAS CITY DISTRICT — U.S. ARMY, JANUARY 1978

Submitted: CHIEF, DAMS & FOUNDATIONS SECT. — Recommended: CHIEF, FOUNDATIONS & MATLS BR. — Approved: CHIEF, ENGINEERING DIVISION

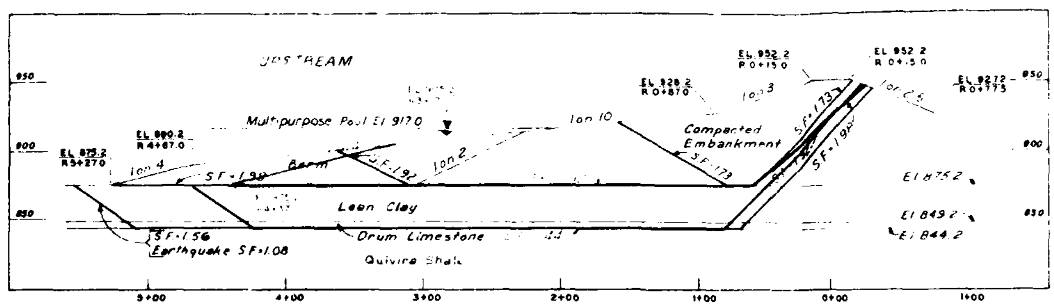
COMPILED BY G.A.D. — DRAWN BY R.L.D. — CHECKED BY R.G.F. — DM-7 — FILE NO. 0-15-676

2

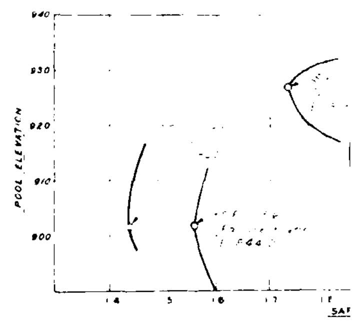
PLATE NO 66



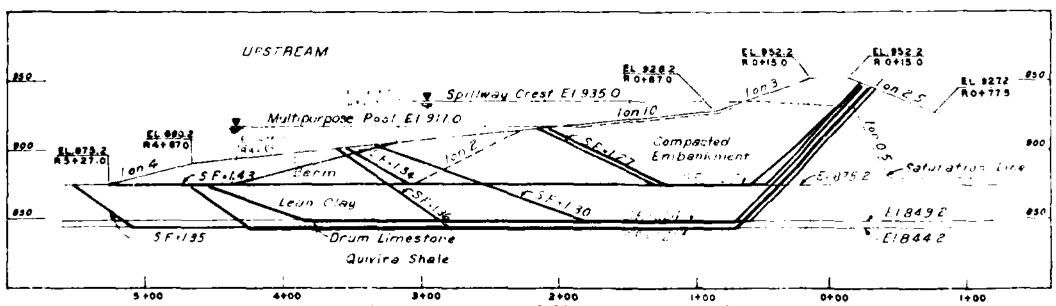
END OF CONSTRUCTION CASE



PARTIAL POOL CASE



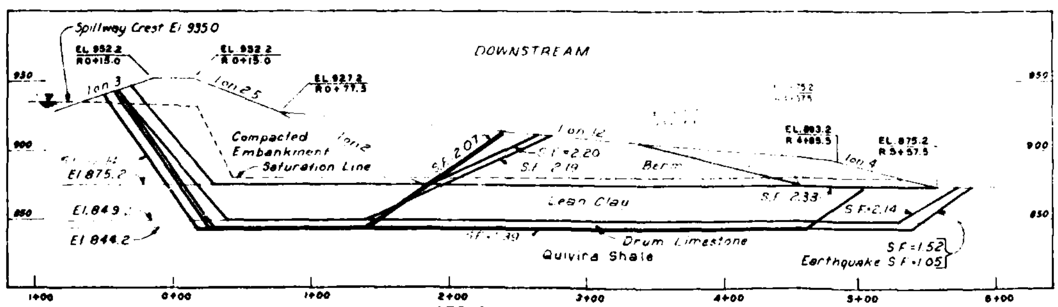
PARTIA



RAPID DRAWDOWN CASE (FROM SPILLWAY CREST)

RAPID DRAWDOWN

EL OF FAILURE PLANE	SAFETY FACTOR FROM SPILLWAY CREST	SAFETY FACTOR FROM MAXIMUM SURCHARGE
875	[illegible]	[illegible]
849	30	[illegible]
844	1.35	32

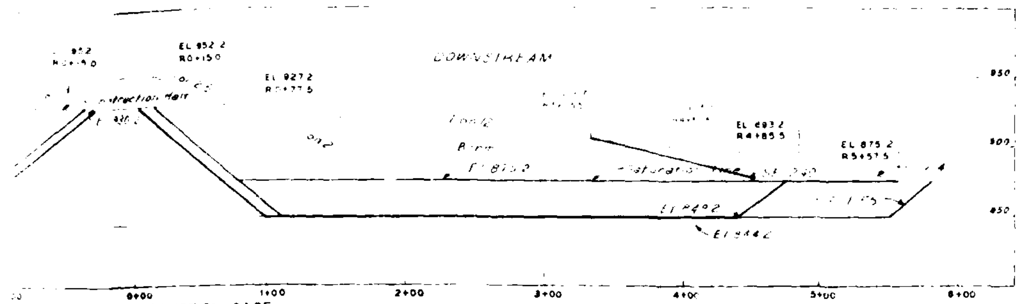


STEADY SEEPAGE CASE

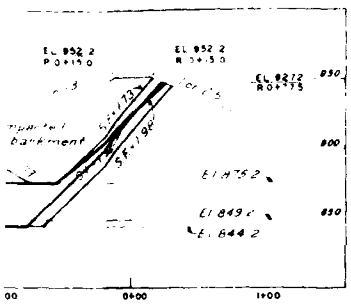
SAFETY FACTORS

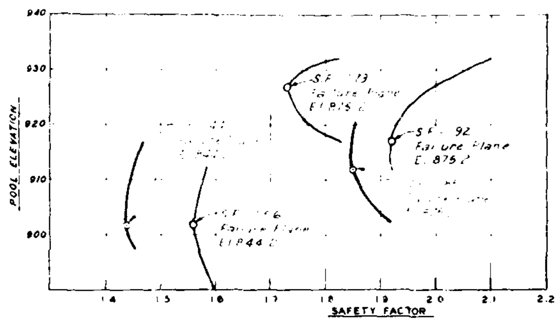
CASE	REQUIRED	ACTUAL
Construction Halt El 930.2	1.4	[illegible]
Rapid Drawdown From Spillway Crest	[illegible]	[illegible]
Rapid Drawdown From Maximum Surcharge	1.0	[illegible]
Partial Pool	1.5	[illegible]
Steady Seepage	1.5	[illegible]
Earthquake	1.0	[illegible]

* For Steady Seepage [illegible]

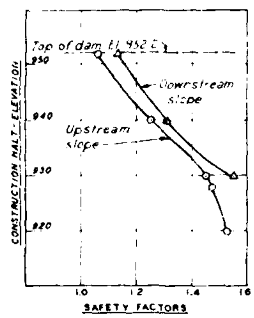


END OF CONSTRUCTION CASE

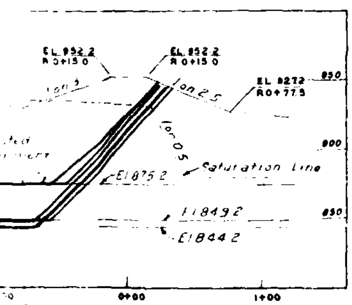




PARTIAL POOL CASE



CONSTRUCTION CASE



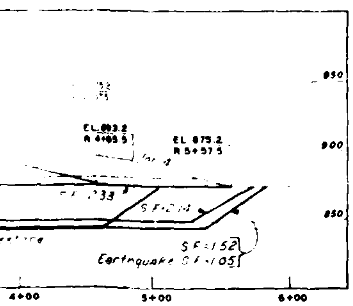
ST)

RAPID DRAWDOWN		
	SAFETY FACTOR	
EL OF FAILURE PLANE	FROM SPILLWAY CREST	FROM MAXIMUM SURCHARGE
875	1.27	1.20
849	1.30	
844	1.35	1.32
[illegible]		
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]

PHYSICAL SOIL CONSTANTS								
MATERIAL	UNIT WEIGHT P/C.F		DESIGN SHEAR STRENGTHS					
			"Q"		"R"		"S"	
	SAT	DRAINED	C (TSF)	TAN Φ	C (TSF)	TAN Φ	C (TSF)	TAN Φ
Compacted Embankment	125	120	.700	.000	.200	.180	.000	.450
Berm Fill	115	110	.100 / .400	.100 / .000	.100	.200	.000	.350
Little Bull Fdn Clays	115	110	.100 / .400	.100 / .000	.100	.200	.000	.450
Drum Limestone	165	—	—	—	—	—	[illegible]	.700
Quivira Underclay (Peak)	140	—	—	—	—	—	.000	.210
Quivira Underclay (Residual)	140			—	—	—	.000	[illegible]

STABILITY STUDIES USING RESIDUAL STRENGTHS FOR FOUNDATION OVERBURDEN AND SHALES		
CASE	SAFETY FACTOR	REVISED SECTION
Steady seepage	1.05	
Partial pool	1.15	
Rapid drawdown from spillway crest	1.01	
Rapid drawdown from maximum surcharge	0.97	

RESIDUAL STRENGHS WERE NOT USED FOR OVERBURDEN IN REVISED SECTION



SAFETY FACTORS			
CASE	REQUIRED	ACTUAL	REVISED SECTION
Construction Halt EL 930.2	1.4	1.45	1.39
Rapid Drawdown From Spillway Crest	[illegible]	[illegible]	[illegible]
Rapid Drawdown From Maximum Surcharge	1.0	[illegible]	[illegible]
Partial Pool	1.5	1.66	[illegible]
Steady Seepage	1.5	1.52	[illegible]
Earthquake	1.0	1.05 *	[illegible]

* For Steady Seepage Case

SYM DESCRIPTION DATE APP'D

REVISIONS

BIG BULL CREEK, KANSAS

HILLSDALE LAKE

2

EMBANKMENT STABILITY ANALYSIS SUMMARY
STATION 104+00

In 1 sheet — Sheet No 1 — Scale: as shown

CORPS OF ENGINEERS, KANSAS CITY DISTRICT — U. S. ARMY — JANUARY 1978

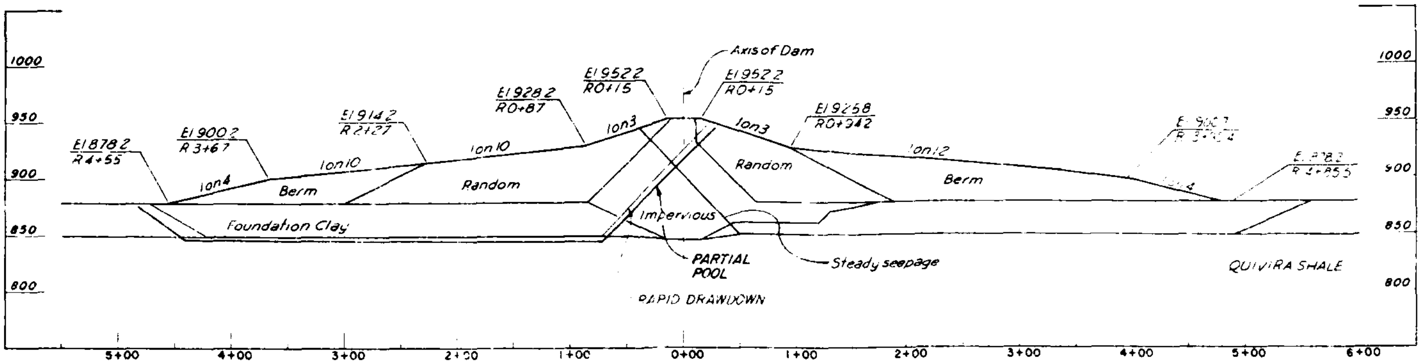
Submitted / Recommended / Approved

CHIEF, DESIGN & FOUNDATION SECT — CHIEF, FOUNDATIONS & MATLS BR — CHIEF, ENGINEERING DIVISION

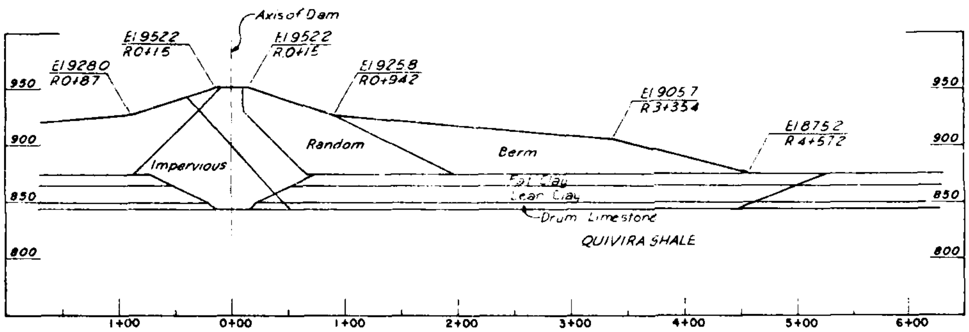
COMPILED BY GAD — DRAWN BY RLD — CHECKED BY RGF — DM-7 — FILE NO 0-15-677

PLATE NO 67

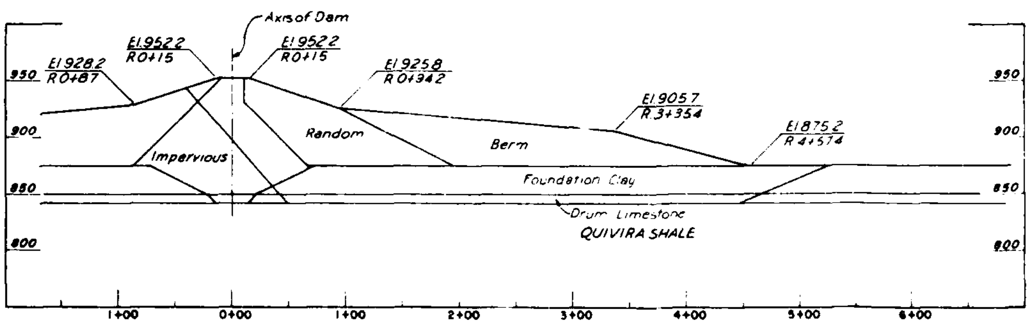
ELEVATION IN FEET BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929



STATION - 81+00
LOWER RIGHT ABUTMENT



STATION - 90+00
MAIN VALLEY

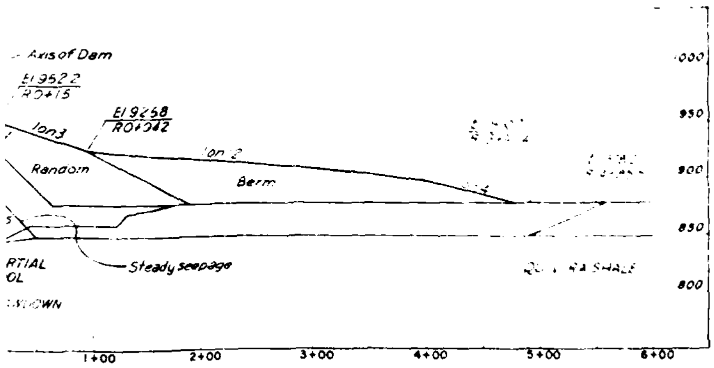


STATION - 104+00
LITTLE BULL AREA

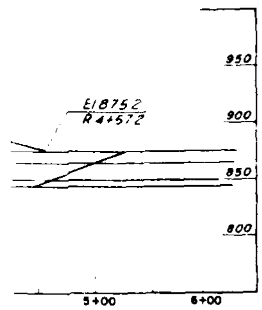
STABILITY STUDIES USING EMBANKMENT STRENGTHS FROM RECORD CONTROL TESTS AND DESIGN FOUNDATION STRENGTHS

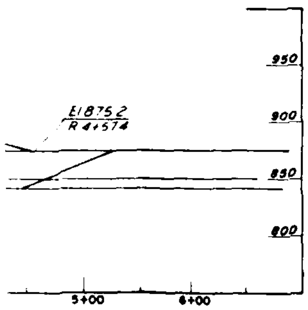
CASE STUDY	SAFETY FACTOR REQUIRED	SAFETY FACTOR FROM STUDIES
RAPID DRAWDOWN FROM SPILLWAY CREST	1.2	1.39
RAPID DRAWDOWN FROM MAXIMUM SURCHARGE	1.0	1.30
PARTIAL POOL (STA 81+00)	1.5	1.54
STEADY SEEPAGE (STA 81+00)	1.5	1.13
STEADY SEEPAGE (STA 90+00)	1.5	1.15
STEADY SEEPAGE (STA 104+00)	1.5	1.15

3 2 1



I-81+00
T ABUTMENT





PHYSICAL SOIL CONSTANTS								
LOWER RIGHT ABUTMENT (STA 81+00)								
MATERIALS	UNIT WEIGHT SAT	UNIT WEIGHT DRAINED	"Q" C	"Q" Tan Ø	"R" C	"R" Tan Ø	"S" C	"S" Tan Ø
BERM	115	110	0.10 / 0.40	0.10 / 0.30	0.10	0.20	0.00	0.35
RANDOM	125	120	1.43	0.00	0.66	0.22	0.00	0.46
IMPERVIOUS	128	120	1.45	0.00	0.65	0.24	0.00	0.46
FOUNDATION CLAY	115	110	0.20 / 0.80	0.20 / 0.00	0.30	0.20	0.00	0.48
QUIVIRA SHALE SEAM	140	—	—	—	—	—	0.00	*0.21
MAIN VALLEY (STA 90+00)								
BERM	115	110	0.10 / 0.40	0.10 / 0.00	0.10	0.20	0.00	0.35
RANDOM	125	120	1.00	0.00	0.44	0.32	0.00	0.46
IMPERVIOUS	125	120	1.32	0.00	0.85	0.22	0.00	0.48
FOUNDATION CLAY (CH)	115	110	0.20 / 0.80	0.20 / 0.00	0.30	0.20	0.00	0.35
FOUNDATION CLAY (CL)	115	110	0.20 / 0.80	0.20 / 0.00	0.30	0.20	0.00	0.45
DRUM LIMESTONE	165	—	—	—	—	—	0.00	0.70
QUIVIRA SHALE SEAM	140	—	—	—	—	—	0.00	*0.21
LITTLE BULL AREA (STA 104+00)								
BERM	115	110	0.10 / 0.40	0.10 / 0.00	0.10	0.20	0.00	0.35
RANDOM	125	120	1.33	0.00	0.55	0.28	0.00	0.47
IMPERVIOUS	125	120	1.32	0.00	0.48	0.29	0.00	0.51
FOUNDATION CLAY (CL)	115	110	0.10 / 0.40	0.10 / 0.00	0.10	0.20	0.00	0.46
DRUM LIMESTONE	165	—	—	—	—	—	0.00	0.70
QUIVIRA SHALE SEAM	140	—	—	—	—	—	0.00	*0.21

* QUIVIRA SHALE STRENGTH REVISED TO C=0.00 TSF AND TAN Ø = 0.37 REPRESENTING A STRENGTH ENVELOPE EXCEEDED BY TWO-THIRDS OF THE DIRECT SHEAR TESTS

STABILITY STUDIES USING EMBANKMENT STRENGTHS FROM RECORD CONTROL TESTS AND DESIGN FOUNDATION STRENGTHS

CASE STUDY	SAFETY FACTOR REQUIRED	SAFETY FACTOR FROM STUDIES
RAPID DRAWDOWN FROM SPILLWAY CREST	1.2	1.39
RAPID DRAWDOWN FROM MAXIMUM SURCHARGE	1.0	1.30
PARTIAL POOL (STA 81+00)	1.5	1.54
STEADY SEEPAGE (STA 81+00)	1.5	1.13
STEADY SEEPAGE (STA 90+00)	1.5	1.15
STEADY SEEPAGE (STA 104+00)	1.5	1.15

STABILITY STUDIES USING EMBANKMENT STRENGTHS FROM RECORD CONTROL TESTS AND REVISED FOUNDATION STRENGTHS

CASE STUDY	SAFETY FACTOR REQUIRED	SAFETY FACTOR FROM STUDIES
RAPID DRAWDOWN FROM SPILLWAY CREST	1.2	2.00
RAPID DRAWDOWN FROM MAXIMUM SURCHARGE	1.0	1.90
PARTIAL POOL (STA 81+00)	1.5	2.17
STEADY SEEPAGE (STA 81+00)	1.5	1.63
STEADY SEEPAGE (STA 90+00)	1.5	1.64
STEADY SEEPAGE (STA 104+00)	1.5	1.64

D

C

B

A

Revisions			
Symbol	Descriptions	Date	Approved

U. S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
KANSAS CITY, MISSOURI

Designed by:
Drawn by:
Checked by:
Submitted by:

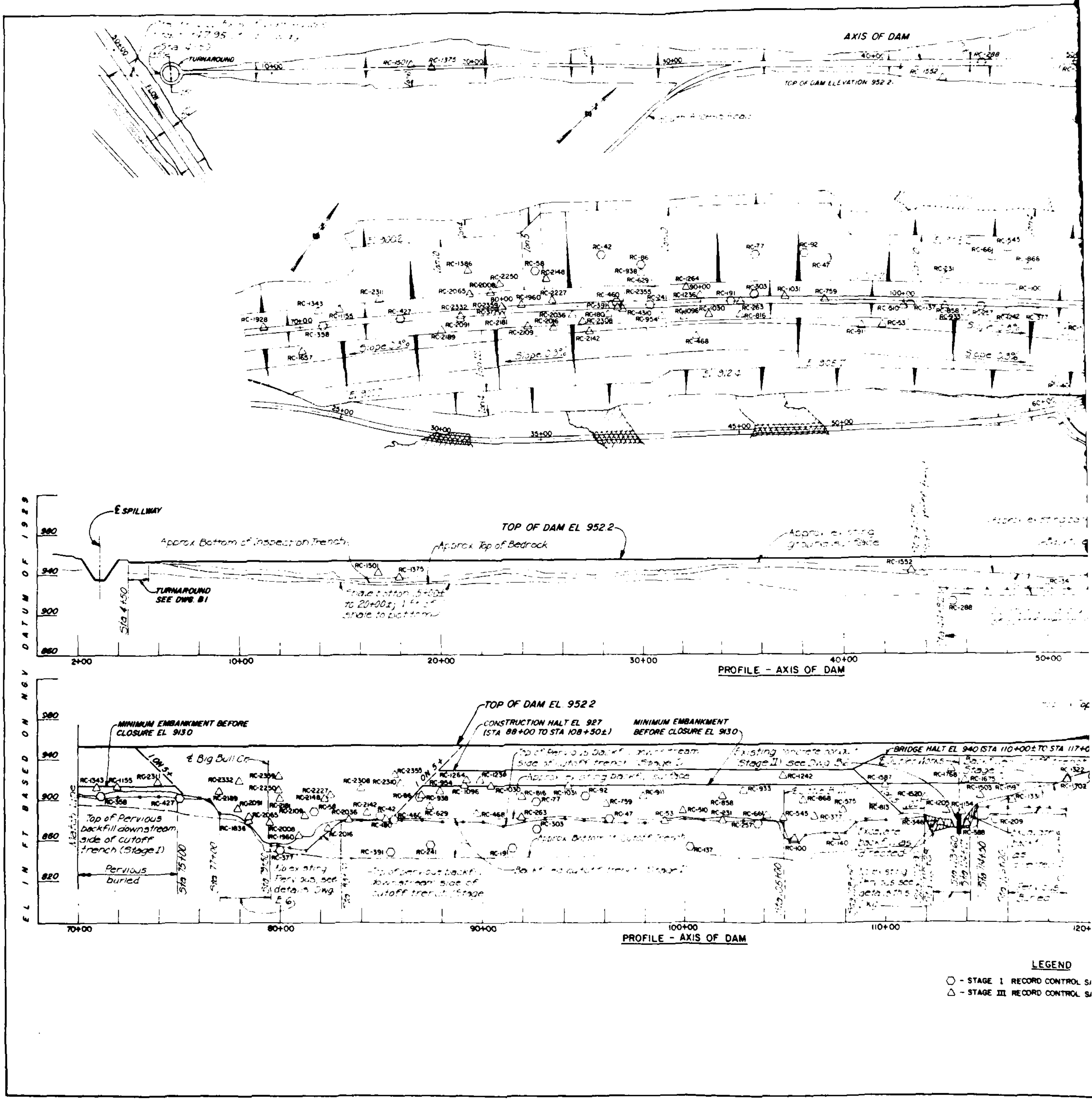
US Army Corps of Engineers

BIG BULL CREEK, KANSAS
HILLSDALE LAKE
EMBANKMENT CRITERIA REPORT

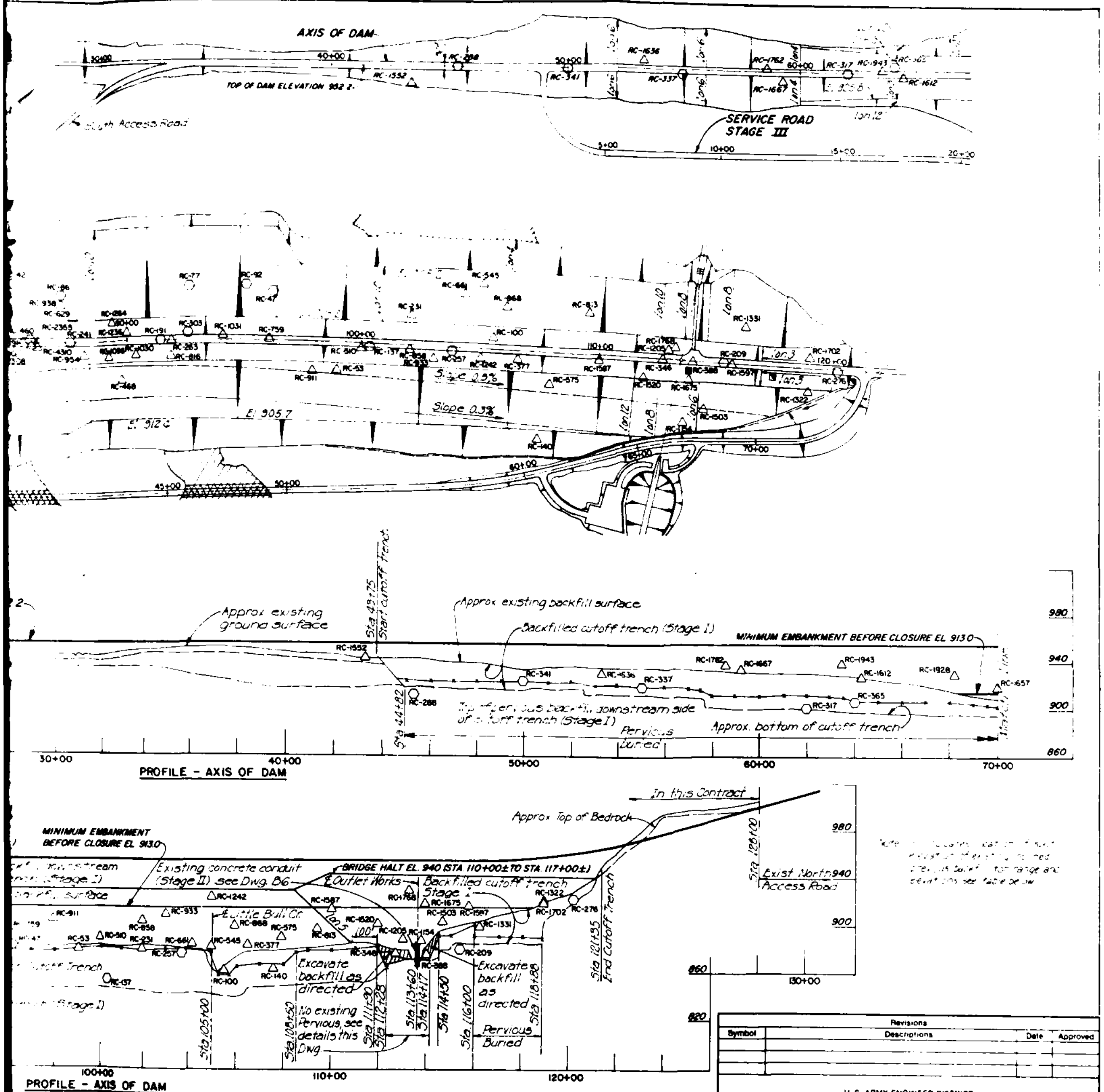
EMBANKMENT STABILITY ANALYSIS SUMMARY

Scale:
Sheet number
Date: SEPTEMBER 1984
Dwg. No.: 1 of 1
File No. 0-15-1062

3 2 1 PLATE NO. 68



AXIS OF DAM
TURNAROUND
TOP OF DAM ELEVATION 952.2
℄ SPILLWAY
TOP OF DAM EL 952.2
Approx Bottom of Inspection Trench
Approx Top of Bedrock
TURNAROUND SEE DWG. B1
PROFILE - AXIS OF DAM
DATUM OF 1929
EL IN FT BASED ON NGV
MINIMUM EMBANKMENT BEFORE CLOSURE EL 913.0
CONSTRUCTION HALT EL 927 (STA 88+00 TO STA 108+50±)
MINIMUM EMBANKMENT BEFORE CLOSURE EL 913.0
BRIDGE HALT EL 940
℄ Big Bull Cr.
Top of Pervious backfill downstream side of cutoff trench (Stage I)
Pervious buried
PROFILE - AXIS OF DAM
LEGEND
○ - STAGE I RECORD CONTROL S
△ - STAGE III RECORD CONTROL S



LEGEND

○ - STAGE I RECORD CONTROL SAMPLE LOCATION
△ - STAGE III RECORD CONTROL SAMPLE LOCATION

Symbol	Descriptions	Date	Approved

Revisions

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
KANSAS CITY, MISSOURI

Designed by:
Drawn by:
Checked by:
Submitted by:

US Army Corps of Engineers

BIG BULL CREEK, KANSAS
HILLSDALE LAKE
EMBANKMENT CRITERIA REPORT

EMBANKMENT CRITERIA AND PERFORMANCE REPORT EMBANKMENT PLAN AND PROFILE RECORD CONTROL SAMPLE LOCATIONS

Scale
Sheet number 1 of 1
Date SEPTEMBER 198[illegible]
Dwg No
File No 0-15-1063

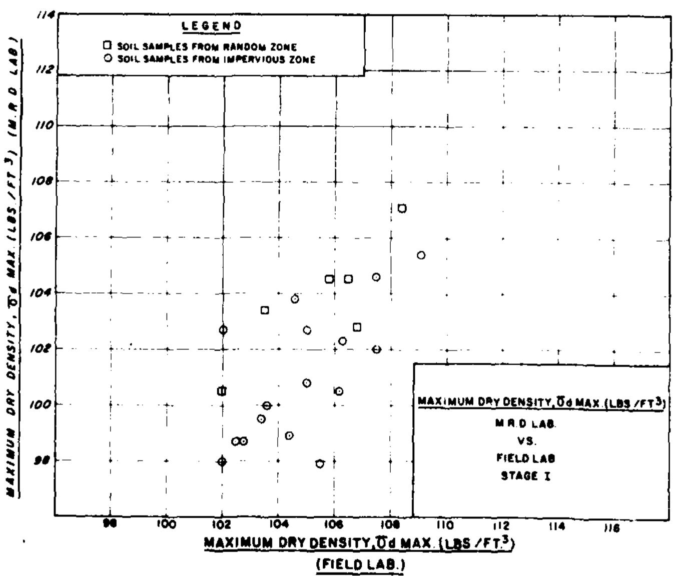
PLATE NO 69

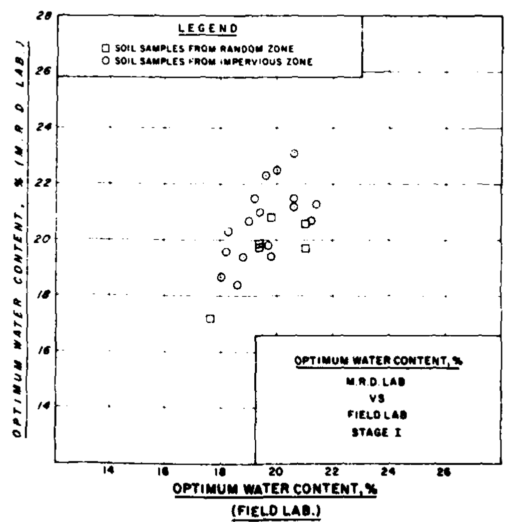
RECORD CONTROL SAMPLE					SOIL CLASSIFICATION DATA								
					FIELD			M.R.D. LABORATORY					
								TRIAXIAL TEST SPECIMEN			COMPACTION TEST SPECIMEN		
NUMBER	STATION	RANGE	ELEVATION	ZONE	LL	PI	CLASS	LL	PI	CLASS	LL	PI	CLASS
RC-42	85+00	2+55U/S	884.0	RANDOM	46	28	CL	52	34	CH	45	30	CL
RC-47	96+30	2+06U/S	881.0	RANDOM	44	26	CL	45	23	CL	42	26	CL
RC-58	80+10	1+85U/S	888.0	RANDOM	48	30	CL	46	31	CL	45	29	CL
RC-77	92+70	2+30U/S	898.0	RANDOM	40	22	CL	48	26	CL	39	23	CL
RC-86	86+95	2+00U/S	902.0	RANDOM	54	34	CH	54	31	CH	49	32	CL
RC-92	95+10	2+35U/S	904.0	RANDOM	51	34	CH	51	30	CH	48	30	CL
RC-137	100+30	0+13D/S	853.0	IMP.	41	22	CL	44	26	CL	41	23	CL
RC-191	91+50	0+06U/S	852.0	IMP	46	31	CL	49	31	CL	43	26	CL
RC-209	115+40	℄	880.0	IMP.	58	40	CH	59	39	CH	50	35	CH
RC-241	87+40	0+50U/S	855.0	IMP.	43	28	CL				38	27	CL
RC-257	103+75	0+15D/S	876.0	IMP.	43	27	CL	45	26	CL	36	24	CL
RC-276	120+20	0+06D/S	922.0	IMP.	51	34	CH	61	43	CH	47	30	CL
RC-288	45+35	0+05U/S	913.0	IMP.	48	31	CL	51	33	CH	50	33	CH
RC-303	92+68	0+30U/S	871.0	IMP.	51	33	CH	60	44	CH	51	35	CH
RC-317	62+00	℄	902.0	IMP.	45	26	CL	54	37	CH	45	28	CL
RC-337	55+00	0+12D/S	920.0	IMP.	54	36	CH	70	52	CH	61	44	CH
RC-341	50+00	℄	925.0	IMP.	53	34	CH	65	48	CH	55	38	CH
RC-358	71+10	℄	904.0	IMP.	44	25	CL	54	37	CH	39	26	CL
RC-365	64+00	0+30U/S	908.0	IMP.	53	33	CH	58	41	CH	56	39	CH
RC-377	80+00	0+06U/S	850.0	IMP.	50	31	CL	59	44	CH	52	35	CH
RC-391	85+50	℄	849.0	IMP.	49		CL	59	43	CH	53	35	CH
RC-427	75+00	℄	903.0	IMP.	50		CH	61	45	CH	51	34	CH
RC-460	85+67	0+14U/S	881.0	IMP.	45	30	CL	51	34	CH	47	32	CL

NUMBER	STANDARD COMPACTION TEST				DENSITY AND MO			
	FIELD		M.R.D. LAB.		SAND CONE DATA			
	MAX. DRY DENSITY (PCF)	OPT. MOIST CONTENT (%)	MAX DRY DENSITY (PCF)	OPT MOIST CONTENT (%)	DRY DENSITY (PCF)	COM-PACTION (%)	WATER CONTENT (%)	WATER CONTENT (±% OPT)
RC-42	106.8	19.8	102.8	20.8	107.2	100.4	20.8	+1.0
RC-47	105.8	21.0	104.5	19.7	103.3	97.6	21.6	+0.6
RC-58	104.5	19.4	104.5	19.9	105.9	101.3	20.5	+1.1
RC-77	108.4	17.6	107.1	17.2	107.5	99.2	17.3	−0.3
RC-86	102.0	21.0	100.5	20.6	105.8	103.7	18.6	−2.4
RC-92	103.5	19.4	103.4	19.8	103.0	99.5	22.1	+2.7
RC-137	104.6	19.7	103.8	19.8	103.4	98.9	22.1	+2.4
RC-191	106.4	18.8	105.1	19.4	103.5	97.3	21.5	+2.7
RC-209	102.0	21.2	98.0	20.7	98.4	96.5	24.5	+3.3
RC-241	109.1	18.0	105.4	18.7	107.3	98.4	15.9	−2.1
RC-257	107.5	18.2	102.0	19.6	107.1	99.6	19.5	+1.3
RC-276	102.0	21.4	102.7	21.3	97.6	95.7	21.8	+0.4
RC-288	103.4	20.6	99.5	21.2	102.5	99.1	18.8	−1.8
RC-303	105.0	19.2	100.8	21.5	103.3	98.4	19.9	+0.7
RC-317	105.0	19.8	102.7	19.4	101.8	97.0	19.6	−0.2
RC-337	104.4	20.6	98.9	23.1	103.1	98.7	22.6	+2.0
RC-341	105.5	19.4	97.9	21.0	104.4	98.9	22.4	+3.0
RC-358	106.3	18.3	102.3	20.3	105.3	99.1	20.9	+2.6
RC-365	102.8	20.0	98.7	22.5	104.8	101.9	21.8	+1.8
RC-377	103.6	20.6	100.0	21.5	101.2	97.7	22.2	+1.6
RC-391	102.5	19.6	98.7	22.3	103.0	100.5	20.0	+0.4
RC-427	106.2	19.0	100.5	20.7	107.0	100.8	20.9	+1.9
RC-460	107.5	18.6	104.6	18.4	109.1	101.4	19.7	+1.7

* UNDISTURBED DATA OBTAINED BY AVERAGING MOISTURE AND DENSITY VALUES OF TRIAXIAL TEST SPECIMENS

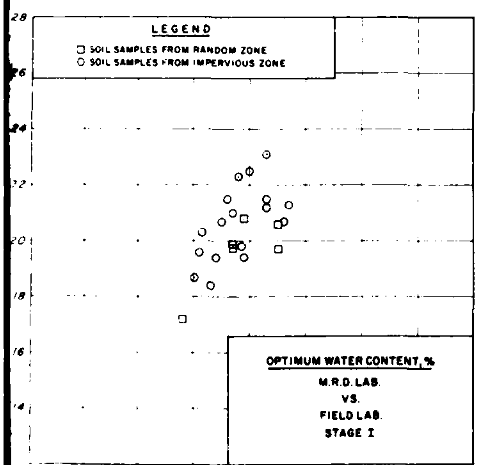
STAGE I RECORD CONTROL SUMMARY





CLASS	STANDARD COMPACTION TEST — FIELD — MAX. DRY DENSITY (PCF)	FIELD — OPT. MOIST CONTENT (%)	M.R.D. LAB. — MAX. DRY DENSITY (PCF)	M.R.D. LAB. — OPT. MOIST CONTENT (%)	DENSITY AND MOISTURE CONTENT — SAND CONE DATA — DRY DENSITY (PCF)	SAND CONE — COM-PACTION (%)	SAND CONE — WATER CONTENT (%)	SAND CONE — WATER CONTENT (±% OPT)	UNDISTURBED DATA — DRY DENSITY (PCF)	UNDISTURBED — COM-PACTION (%)	UNDISTURBED — WATER CONTENT (%)	UNDISTURBED — WATER CONTENT (±% OPT)
CL	106.8	19.8	102.8	20.8	107.2	100.4	20.8	+1.0	*106.4	99.6	*21.4	+1.6
CL	105.8	21.0	104.5	19.7	103.3	97.6	21.6	+0.6	*104.4	98.7	*22.2	+1.2
CL	104.5	19.4	104.5	19.9	105.9	101.3	20.5	+1.1	104.4	99.9	20.7	+1.3
CL	108.4	17.6	107.1	17.2	107.5	99.2	17.3	−0.3	*113.4	104.6	*17.4	-0.2
CL	102.0	21.0	100.5	20.6	105.8	103.7	18.6	−2.4	104.3	102.2	19.9	−1.1
CL	103.5	19.4	103.4	19.8	103.0	99.5	22.1	+2.7	*103.7	100.2	*22.4	+3.0
CL	104.6	19.7	103.8	19.8	103.4	98.9	22.1	+2.4	105.2	100.6	20.7	+1.0
CL	106.4	18.8	105.1	19.4	103.5	97.3	21.5	+2.7	*104.7	98.4	*20.6	+1.8
CH	102.0	21.2	98.0	20.7	98.4	96.5	24.5	+3.3	101.1	99.1	23.1	+1.9
CL	109.1	18.0	105.4	18.7	107.3	98.4	15.9	−2.1	*107.2	98.3	*15.4	−2.6
CL	107.5	18.2	102.0	19.6	107.1	99.6	19.5	+1.3	*108.6	101.0	*19.2	+1.0
CL	102.0	21.4	102.7	21.3	97.6	95.7	21.8	+0.4	*103.5	101.5	*21.4	0.0
CH	103.4	20.6	99.5	21.2	102.5	99.1	18.8	−1.8	102.9	99.5	19.1	−1.5
CH	105.0	19.2	100.8	21.5	103.3	98.4	19.9	+0.7	*108.0	102.9	*19.7	+0.5
CL	105.0	19.8	102.7	19.4	101.8	97.0	19.6	−0.2	101.6	96.8	19.9	+0.1
CH	104.4	20.6	98.9	23.1	103.1	98.7	22.6	+2.0	98.1	94.0	24.3	+3.7
CH	105.5	19.4	97.9	21.0	104.4	98.9	22.4	+3.0	104.7	99.2	21.4	+2.0
CL	106.3	18.3	102.3	20.3	105.3	99.1	20.9	+2.6	102.6	96.5	21.4	+3.1
CH	102.8	20.0	98.7	22.5	104.8	101.9	21.8	+1.8	99.5	96.8	21.8	+1.8
CH	103.6	20.6	100.0	21.5	101.2	97.7	22.2	+1.6	100.2	96.7	22.0	+1.2
CH	102.5	19.6	98.7	22.3	103.0	100.5	20.0	+0.4	96.6	94.2	20.7	+1.1
CH	106.2	19.0	100.5	20.7	107.0	100.8	20.9	+1.9	103.4	97.4	20.2	+1.2
CL	107.5	18.6	104.6	18.4	109.1	101.4	19.7	+1.7	109.1	101.5	19.8	+1.2

CONTROL SUMMARY



Revisions			
Symbol	Descriptions	Date	Approved

U. S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
KANSAS CITY, MISSOURI

Designed by:
Drawn by:
Checked by:
Submitted by:

US Army Corps of Engineers

BIG BULL CREEK, KANSAS
HILLSDALE LAKE
EMBANKMENT CRITERIA REPORT

RECORD CONTROL DATA - STAGE I
STANDARD COMPACTION TEST
LABORATORY VS FIELD

Scale | Sheet number
Date SEPTEMBER 1984
Dwg. No. 1 of 1 | File No. 0-15-1064

PLATE NO. 70

RECORD CONTROL SAMPLE					SOIL CLASSIFICATION DATA									STANDARD COMPACTION TEST				DENSITY AND MO			
					FIELD			M.R.D. LABORATORY						FIELD		M.R.D. LAB		SAND CONE DATA			
								TRIAXIAL TEST SPECIMEN			COMPACTION TEST SPECIMEN										
NUMBER	STATION	RANGE	ELEVATION	ZONE	LL	PI	CLASS	LL	PI	CLASS	LL	PI	CLASS	MAX. DRY DENSITY (PCF)	OPT. MOIST CONTENT (%)	MAX DRY DENSITY (PCF)	OPT MOIST CONTENT (%)	DRY DENSITY (PCF)	COM-PACTION (%)	WATER CONTENT (%)	WATER CONTENT (±%OPT)
RC-1501	17+00	0+15U/S	941.0	IMP.	74	52	CH	70	50	CH	83	65	CH	95.0	24.8	93.3	24.8	98.8	104.0	25.2	+0.4
RC-1503	114+65	2+00D/S	901.5	IMP.	37	21	CL	36	20	CL	35	18	CL	112.2	15.5	111.7	15.3	110.8	98.7	17.4	+1.9
RC-1520	112+00	0+80D/S	901.0	IMP	35	21	CL	36	21	CL	40	28	CL	112.2	15.6	112.5	15.6	110.6	98.6	17.6	+2.0
RC-1552	43+40	0+70D/S	943.0	IMP.	57	36	CH	64	50	CH	62	47	CH	101.0	21.2	101.8	20.2	102.2	101.1	21.8	+0.6
RC-1587	110+00	0+20D/S	912.6	IMP.	30	15	CL	29	15	CL	30	16	CL	116.3	13.4	114.8	13.7	116.8	100.4	14.8	+1.4
RC-1597	115+75	0+50D/S	914.5	IMP.	28	14	CL	31	15	CL	30	16	CL	116.7	13.7	117.4	12.7	103.7	97.4	14.2	+0.5
RC-1612	64+30	0+18D/S	927.5	IMP.	46	29	CL	52	37	CH	54	37	CH	104.2	18.8	104.8	19.5	106.9	102.6	20.1	+1.3
RC-1636	53+30	0+35U/S	930.0	IMP.	54	33	CH	59	44	CH	62	46	CH	101.6	21.1	101.5	21.1	103.2	101.6	21.4	+0.3
RC-1657	70+00	1+20D/S	920.0	RANDOM	49	31	CL	56	42	CH	55	41	CH	103.5	19.9	101.4	20.7	100.8	97.4	23.4	+3.5
RC-1667	59+30	0+40D/S	934.0	IMP.	46	29	CL	59	45	CH	49	36	CL	107.3	18.0	107.1	18.2	111.8	104.2	16.6	-1.4
RC-1675	114+00	0+80D/S	917.0	IMP.	43	28	CL	51	38	CH	47	35	CL	109.4	16.0	109.5	16.3	108.4	99.0	18.6	+2.6
RC-1702	119+00	0+45U/S	920.0	RANDOM	41	23	CL	52	38	CH	43	29	CL	106.9	17.3	106.7	19.4	110.0	102.8	17.2	-0.1
RC-1762	58+60	0+15U/S	937.0	IMP.	40	25	CL	42	30	CL	36	21	CL	110.7	16.2	113.2	14.6	114.0	103.0	15.2	-1.0
RC-1768	113+30	0+55U/S	929.5	IMP.	39	20	CL	42	28	CL	36	18	CL	107.1	16.8	109.2	16.3	106.8	99.8	18.3	+1.5
RC-1836	78+50	2+10U/S	879.0	IMP.	56	38	CH	67	53	CH	57	43	CH	104.0	20.2	102.0	20.1	106.4	101.4	19.6	-0.6
RC-1928	68+20	0+20U/S	931.0	IMP.	32	18	CL	38	28	CL	33	22	CL	114.3	14.4	114.7	14.7	120.0	105.0	12.0	-2.4
RC-1943	63+50	0+12U/S	940.0	IMP.	54	35	CH	66	51	CH	55	40	CH	103.2	20.4	101.4	22.7	107.2	104.0	19.7	+0.7
RC-1960	81+00	0+20U/S	864.6	IMP.	40	23	CL	53	38	CH	39	25	CL	108.6	17.5	107.7	17.8	108.0	99.5	18.6	+1.1
RC-2008	79+50	0+90U/S	877.8	RANDOM	41	25	CL	54	40	CH	45	31	CL	108.3	17.2	107.3	18.7	110.2	101.8	18.7	+1.5
RC-2016	82+50	1+00D/S	871.5	RANDOM	43	28	CL	54	43	CH	44	30	CL	111.0	16.1	108.4	18.0	110.2	99.3	17.2	+1.1
RC-2036	83+45	0+37D/S	880.0	IMP.	37	21	CL	37	21	CL	36	22	CL	110.1	16.1	109.1	17.0	111.4	101.1	17.9	+1.8
RC-2065	78+50	0+90U/S	884.0	RANDOM	50	33	CH	60	47	CH	51	37	CH	105.0	19.0	106.3	18.5	111.4	106.0	17.2	-1.8
RC-2091	78+00	0+30D/S	891.5	IMP.	34	20	CL	30	17	CL	33	22	CL	113.0	15.5	112.3	15.7	113.1	100.0	15.4	-0.1
RC-2109	81+25	0+85D/S	884.0	RANDOM	49	32	CL	47	32	CL	48	34	CL	107.0	18.8	104.3	20.0	107.6	100.6	20.1	+1.3
RC-2142	84+30	1+25D/S	887.5	RANDOM	70	50	CH	75	58	CH	75	58	CH	96.6	23.7	92.8	24.2	99.0	102.6	23.8	+0.1
RC-2148	82+25	1+45U/S	901.0	RANDOM	46	30	CL	51	38	CH	49	34	CL	105.9	19.0	103.9	19.3	104.5	98.7	21.0	+2.0
RC-2181	80+00	0+25D/S	902.0	IMP.	50	34	CL	53	35	CH	53	39	CH	106.8	18.9	106.3	19.4	101.4	94.9	19.0	+0.1
RC-2189	77+00	0+75D/S	908.0	RANDOM	57	41	CH	61	41	CH	32	14	CL	103.8	20.7	100.3	22.0	106.0	102.1	21.0	+0.3
RC-2227	82+50	0+35U/S	905.0	IMP.	57	40	CH	48	33	CL	59	46	CH	102.6	20.3	100.8	20.8	101.5	98.9	19.2	-1.1
RC-2250	80+00	1+25U/S	910.0	RANDOM	59	41	CH	53	37	CH	59	45	CH	100.0	21.8	102.3	22.2	103.5	103.5	19.7	-2.1

STAGE III RECORD CONTROL SUMMARY

...A		STANDARD COMPACTION TEST				DENSITY AND MOISTURE CONTENT							
...ATORY		FIELD		M.R.D. LAB		SAND CONE DATA				UNDISTURBED DATA			
COMPACTION TEST SPECIMEN PI	CLASS	MAX. DRY DENSITY (PCF)	OPT. MOIST CONTENT (%)	MAX DRY DENSITY (PCF)	OPT. MOIST CONTENT (%)	DRY DENSITY (PCF)	COM-PACTION (%)	WATER CONTENT (%)	WATER CONTENT (±% OPT)	DRY DENSITY (PCF)	COM-PACTION (%)	WATER CONTENT (%)	WATER CONTENT (±% OPT)
65	CH	95.0	24.8	93.3	24.8	98.8	104.0	25.2	+0.4	96.8	101.9	25.8	+1.0
18	CL	112.2	15.5	111.7	15.3	110.8	98.7	17.4	+1.9	108.8	97.0	17.7	+2.2
28	CL	112.2	15.6	112.5	15.6	110.6	98.6	17.6	+2.0	110.6	98.6	15.9	+0.3
47	CH	101.0	21.2	101.8	20.2	102.2	101.1	21.8	+0.6	100.4	99.4	22.4	+1.2
16	CL	116.3	13.4	114.8	13.7	116.8	100.4	14.8	+1.4	115.1	99.0	15.5	+2.1
16	CL	116.7	13.7	117.4	12.7	103.7	97.4	14.2	+0.5	112.7	96.6	15.6	+1.9
37	CH	104.2	18.8	104.8	19.5	106.9	102.6	20.1	+1.3	102.9	98.8	21.3	+2.5
46	CH	101.6	21.1	101.5	21.1	103.2	101.6	21.4	+0.3	105.5	103.8	21.6	+0.5
41	CH	103.5	19.9	101.4	20.7	100.8	97.4	23.4	+3.5	100.0	96.3	22.2	+2.3
36	CL	107.3	18.0	107.1	18.2	111.8	104.2	16.6	-1.4	107.4	100.0	21.1	+3.1
35	CL	109.4	16.0	109.5	16.3	108.4	99.0	18.6	+2.6	105.3	96.3	19.8	+3.8
29	CL	106.9	17.3	106.7	19.4	110.0	102.8	17.2	-0.1	111.3	104.1	17.0	-0.3
21	CL	110.7	16.2	113.2	14.6	114.0	103.0	15.2	-1.0	110.0	99.4	14.8	-1.4
18	CL	107.1	16.8	109.2	16.3	106.8	99.8	18.3	+1.5	105.4	98.4	18.7	+1.9
43	CH	104.0	20.2	102.0	20.1	106.4	101.4	19.6	-0.6	102.8	98.8	21.3	+1.1
22	CL	114.3	14.4	114.7	14.7	120.0	105.0	12.0	-2.4	116.6	102.0	12.6	-1.8
40	CH	103.2	20.4	101.4	22.7	107.2	104.0	19.7	+0.7	103.4	100.2	21.4	+1.0
25	CL	108.6	17.5	107.7	17.8	108.0	99.5	18.6	+1.1	103.1	94.9	20.2	+2.7
31	CL	108.3	17.2	107.3	18.7	110.2	101.8	18.7	+1.5	107.5	99.3	19.8	+2.6
30	CL	111.0	16.1	108.4	18.0	110.2	99.3	17.2	+1.1	107.2	96.6	19.6	+3.5
22	CL	110.1	16.1	109.1	17.0	111.4	101.1	17.9	+1.8	109.8	99.7	18.3	+2.2
37	CH	105.0	19.0	106.3	18.5	111.4	106.0	17.2	-1.8	107.4	102.3	19.0	+0.0
22	CL	113.0	15.5	112.3	15.7	113.1	100.0	15.4	-0.1	113.4	100.4	15.0	-0.5
34	CL	107.0	18.8	104.3	20.0	107.6	100.6	20.1	+1.3	110.7	103.5	20.4	+1.6
58	CH	96.6	23.7	92.8	24.2	99.0	102.6	23.8	+0.1	96.8	100.2	24.9	+1.2
34	CL	105.9	19.0	103.9	19.3	104.5	98.7	21.0	+2.0	100.8	95.2	21.6	+2.6
39	CH	106.8	18.9	106.3	19.4	101.4	94.9	19.0	+0.1	103.3	96.7	20.9	+2.0
14	CL	103.8	20.7	100.3	22.0	106.0	102.1	21.0	+0.3	101.1	97.4	22.7	+2.0
46	CH	102.6	20.3	100.8	20.8	101.5	98.9	19.2	-1.1	101.6	99.0	21.6	+1.3
45	CH	100.0	21.8	102.3	22.2	103.5	103.5	19.7	-2.1	102.8	102.8	18.7	-3.1

...ECORD CONTROL SUMMARY

Revisions			
Symbol	Descriptions	Date	Approved

U. S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
KANSAS CITY, MISSOURI

Designed by:
Drawn by:
Checked by:
Submitted by:

BIG BULL CREEK, KANSAS
HILLSDALE LAKE
EMBANKMENT CRITERIA REPORT

RECORD CONTROL DATA - STAGE III
STANDARD COMPACTION TEST
LABORATORY VS FIELD

Scale:
Date: SEPTEMBER 1984
Dwg. No.:
Sheet number: 1 of 5
File No. 0-15-1065

PLATE NO 71

RECORD CONTROL SAMPLE					SOIL CLASSIFICATION DATA									STANDARD COMPACTION TEST				DENSITY AND MOISTU				
					FIELD			M.R.D. LABORATORY						FIELD		M.R.D. LAB.		SAND CONE DATA				L
								TRIAXIAL TEST SPECIMEN			COMPACTION TEST SPECIMEN											
NUMBER	STATION	RANGE	ELEVATION	ZONE	LL	PI	CLASS	LL	PI	CLASS	LL	PI	CLASS	MAX DRY DENSITY (PCF)	OPT MOIST CONTENT (%)	MAX DRY DENSITY (PCF)	OPT MOIST CONTENT (%)	DRY DENSITY (PCF)	COM-PACTION (%)	WATER CONTENT (%)	WATER CONTENT (±%OPT)	DRY DENSI (PCF)
RC-53	99+00	1+15D/S	878.0	RANDOM	53	32	CH	53	35	CH	51	32	CH	105.0	20.0	100.4	21.7	103.8	98.8	19.7	-0.3	100.6
RC-100	105+50	0+50U/S	862.0	IMP.	53	31	CH	58	38	CH	51	34	CH	101.6	21.1	102.1	21.0	102.1	100.5	23.1	+2.0	102.5
RC-140	107+60	3+70D/S	863.0	RANDOM	44	24	CL	49	32	CL	44	26	CL	105.3	19.7	102.2	19.7	107.9	102.5	20.4	+0.7	107.8
RC-180	85+25	0+45D/S	881.0	IMP.	47	28	CL	52	34	CH	49	30	CL	105.0	19.0	105.5	19.0	104.9	104.8	18.2	-0.8	112.3
RC-231	102+00	1+25D/S	879.0	RANDOM	49	30	CL	53	37	CH	44	28	CL	104.5	19.7	103.5	19.7	104.9	100.4	21.3	+1.6	102.3
RC-263	92+00	℄	882.0	IMP.	48	28	CL	54	37	CH	45	27	CL	105.8	18.9	103.7	18.9	110.1	100.6	20.7	+1.8	101.9
RC-346	112+75	℄	876.7	IMP	43	26	CL	53	37	CH	51	34	CH	105.5	18.2	102.7	18.2	103.7	99.2	19.8	+1.6	102.7
RC-377	106+60	0+35D/S	883.0	IMP	56	37	CH	52	36	CH	55	36	CH	101.6	21.0	94.8	21.0	101.4	99.8	23.4	+2.4	98.2
RC-388	114+50	℄	875.0	IMP.	38	18	CL	36	20	CL	37	20	CL	107.6	17.0	101.0	17.0	105.9	101.8	18.6	+1.6	106.3
RC-468	89+80	1+70D/S	886.0	RANDOM	53	33	CH	55	38	CH	54	36	CH	101.6	21.6	87.0	21.6	100.7	99.1	24.9	+3.3	95.7
RC-510	100+00	0+26D/S	888.0	IMP.	42	26	CL	39	25	CL	46	33	CL	107.0	18.7	105.1	18.7	107.7	100.6	18.8	+0.1	106.1
RC-545	106+00	2+75U/S	881.3	RANDOM	41	24	CL	40	26	CL	42	30	CL	109.8	16.9	107.2	16.9	113.8	103.6	18.5	+1.6	109.8
RC-575	108+00	1+35D/S	890.0	RANDOM	42	25	CL	42	27	CL	50	35	CH	105.6	18.9	105.0	18.9	107.0	101.4	19.3	+0.4	103.5
RC-629	87+50	1+00D/S	893.0	RANDOM	47	30	CL	52	36	CH	52	36	CH	106.2	19.1	93.7	19.1	104.2	98.2	19.0	-0.1	103.1
RC-661	104+20	2+25U/S	884.0	RANDOM	43	27	CL	50	35	CH	46	30	CL	109.4	17.9	101.6	17.9	109.6	100.2	18.5	+0.6	108.3
RC-759	96+15	0+05U/S	896.0	IMP.	42	26	CL	48	31	CL	43	27	CL	107.7	18.7	102.5	18.7	108.9	101.2	19.3	+0.6	104.4
RC-813	109+40	1+75U/S	896.6	RANDOM	45	27	CL	41	25	CL	40	24	CL	109.2	17.1	105.7	17.1	110.6	101.2	19.0	+1.9	108.8
RC-816	92+00	0+70D/S	902.5	RANDOM	49	31	CL	45	30	CL	51	37	CH	107.3	18.6	102.1	18.6	109.0	101.5	18.1	-0.5	108.0
RC-858	102+00	0+20D/S	903.5	IMP.	31	18	CL	34	20	CL	30	16	CL	117.2	13.3	109.6	13.3	115.8	98.8	15.2	+1.9	109.3
RC-868	106+00	1+80U/S	899.5	RANDOM	42	25	CL	46	32	CL	36	23	CL	109.7	17.3	104.7	17.3	106.1	96.7	19.9	+2.6	107.7
RC-901	——	——	878.5	——	-	-	-	49	33	CL	44	27	CL	——	——	99.2	——	——	——	——	——	100.8
RC-911	98+00	1+25D/S	904.0	RANDOM	40	24	CL	44	31	CL	33	20	CL	109.9	19.3	106.0	19.3	109.2	99.4	19.3	0.0	107.4
RC-933	103+05	0+55D/S	908.6	RANDOM	39	24	CL	43	30	CL	37	21	CL	111.4	16.6	103.2	16.6	108.7	97.6	16.8	+0.2	110.1
RC-938	87+00	1+60U/S	904.5	RANDOM	44	28	CL	56	42	CH	52	38	CH	108.5	17.2	104.8	17.2	111.6	102.8	18.0	+0.8	104.5
RC-954	88+00	0+60D/S	908.0	RANDOM	37	22	CL	41	28	CL	40	27	CL	112.9	15.9	111.3	15.9	111.4	98.8	15.8	-0.1	110.9
RC-1030	90+45	0+60D/S	913.0	RANDOM	37	21	CL	37	21	CL	43	28	CL	110.1	16.5	108.2	16.5	108.6	98.6	18.3	+1.8	106.3
RC-1031	94+20	0+15U/S	912.0	IMP.	40	24	CL	42	28	CL	39	23	CL	109.2	16.8	108.0	16.8	107.3	98.3	20.2	+3.4	106.2
RC-1096	89+15	0+70D/S	913.5	RANDOM	52	25	CH	57	40	CH	56	43	CH	104.8	19.0	102.6	19.0	104.5	99.7	21.0	+2.0	101.2
RC-1154	113+80	2+60D/S	887.0	IMP	37	20	CL	51	34	CH	35	18	CL	108.0	17.0	108.2	17.8	109.6	101.5	18.3	+1.3	112.1
RC-1155	72+00	0+70U/S	912.5	RANDOM	42	26	CL	48	29	CL	45	31	CL	106.4	19.0	104.5	18.7	103.1	96.9	22.6	+3.6	96.2
RC-1205	113+00	0+40U/S	888.0	IMP	36	19	CL	52	36	CH	38	22	CL	107.9	17.7	107.0	15.8	110.9	102.8	18.8	+1.1	105.4
RC-1236	90+00	0+35U/S	919.0	IMP.	48	30	CL	54	36	CH	50	34	CH	103.4	20.4	96.2	22.7	101.4	98.1	20.8	+0.4	101.4
RC-1242	105+00	0+400/S	922.5	RANDOM	43	27	CL	56	43	CH	39	25	CL	108.9	17.5	102.4	21.3	108.9	100.0	19.1	+1.6	106.6
RC-1264	89+25	0+70U/S	918.8	RANDOM	29	16	CL	35	22	CL	31	21	CL	116.9	13.6	116.3	13.9	113.3	96.9	17.0	+3.4	108.7
RC-1322	119+00	1+02D/S	921.0	IMP.	42	24	CL	52	34	CH	45	31	CL	105.6	18.6	98.7	19.1	100.5	95.2	20.0	+1.4	103.1
RC-1331	116+20	1+60U/S	899.0	RANDOM	38	19	CL	38	18	CL	38	20	CL	106.5	17.4	103.6	18.5	104.9	98.5	19.7	+2.3	102.3
RC-1343	70+90	0+75U/S	912.0	RANDOM	39	25	CL	32	17	CL	40	28	CL	111.2	16.1	111.5	15.7	107.2	96.4	16.1	0.0	110.5
RC-1375	18+00	℄	938.0	IMP	63	43	CH	77	61	CH	69	53	CH	98.5	23.5	98.7	22.8	97.5	99.0	25.8	+2.3	96.1

STAGE III RECORD CONTROL SUMMARY

...ORY		STANDARD COMPACTION TEST				DENSITY AND MOISTURE CONTENT							
...OMPACTION ...ST SPECIMEN		FIELD		M.R.D. LAB.		SAND CONE DATA				UNDISTURBED DATA			
PI	CLASS	MAX DRY DENSITY (PCF)	OPT MOIST CONTENT (%)	MAX DRY DENSITY (PCF)	OPT. MOIST CONTENT (%)	DRY DENSITY (PCF)	COM-PACTION (%)	WATER CONTENT (%)	WATER CONTENT (±% OPT)	DRY DENSITY (PCF)	COM-PACTION (%)	WATER CONTENT (%)	WATER CONTENT (±% OPT)
32	CH	105.0	20.0	100.4	21.7	103.8	98.8	19.7	-0.3	100.6	95.8	22.1	+2.1
34	CH	101.6	21.1	102.1	21.0	102.1	100.5	23.1	+2.0	102.5	100.9	23.1	+2.0
26	CL	105.3	19.7	102.2	19.7	107.9	102.5	20.4	+0.7	107.8	102.4	20.9	+1.2
30	CL	105.0	19.0	105.5	19.0	104.9	104.8	18.2	-0.8	112.3	107.0	17.8	-1.2
28	CL	104.5	19.7	103.5	19.7	104.9	100.4	21.3	+1.6	102.3	97.9	21.5	+1.8
27	CL	105.8	18.9	103.7	18.9	110.1	100.6	20.7	+1.8	101.9	96.3	22.7	+3.8
34	CH	105.5	18.2	102.7	18.2	103.7	99.2	19.8	+1.6	102.7	97.3	20.4	+2.2
36	CH	101.6	21.0	94.8	21.0	101.4	99.8	23.4	+2.4	98.2	96.7	23.7	+2.7
20	CL	107.6	17.0	101.0	17.0	105.9	101.8	18.6	+1.6	106.3	98.8	18.7	+1.7
36	CH	101.6	21.6	87.0	21.6	100.7	99.1	24.9	+3.3	95.7	94.2	25.2	+3.6
33	CL	107.0	18.7	105.1	18.7	107.7	100.6	18.8	+0.1	106.1	99.2	18.1	-0.6
30	CL	109.8	16.9	107.2	16.9	113.8	103.6	18.5	+1.6	109.8	100.0	17.7	+0.8
35	CH	105.6	18.9	105.0	18.9	107.0	101.4	19.3	+0.4	103.5	98.0	20.1	+1.2
36	CH	106.2	19.1	93.7	19.1	104.2	98.2	19.0	-0.1	103.1	97.1	20.8	+1.7
30	CL	109.4	17.9	101.6	17.9	109.6	100.2	18.5	+0.6	108.3	99.0	18.4	+0.5
27	CL	107.7	18.7	102.5	18.7	108.9	101.2	19.3	+0.6	104.4	96.9	21.1	+2.4
24	CL	109.2	17.1	105.7	17.1	110.6	101.2	19.0	+1.9	108.8	99.6	19.3	+2.2
37	CH	107.3	18.6	102.1	18.6	109.0	101.5	18.1	-0.5	108.0	100.6	18.3	-0.3
16	CL	117.2	13.3	109.6	13.3	115.8	98.8	15.2	+1.9	109.3	93.3	15.8	+2.5
23	CL	109.7	17.3	104.7	17.3	106.1	96.7	19.9	+2.6	107.7	98.7	18.4	+1.1
27	CL	—	—	99.2	—	—	—	—	—	100.8	—	20.7	—
20	CL	109.9	19.3	106.0	19.3	109.2	99.4	19.3	0.0	107.4	97.7	20.7	+1.4
21	CL	111.4	16.6	103.2	16.6	108.7	97.6	16.8	+0.2	110.1	98.8	16.7	+0.1
38	CH	108.5	17.2	104.8	17.2	111.6	102.8	18.0	+0.8	104.5	96.3	19.6	+2.4
27	CL	112.9	15.9	111.3	15.9	111.4	98.8	15.8	-0.1	110.9	98.2	16.4	+0.5
28	CL	110.1	16.5	108.2	16.5	108.6	98.6	18.3	+1.8	106.3	96.5	18.6	+2.1
23	CL	109.2	16.8	108.0	16.8	107.3	98.3	20.2	+3.4	106.2	97.3	19.3	+2.5
43	CH	104.8	19.0	102.6	19.0	104.5	99.7	21.0	+2.0	101.2	96.5	20.8	+1.8
18	CL	108.0	17.0	108.2	17.8	109.6	101.5	18.3	+1.3	112.1	103.8	18.3	+1.3
31	CL	106.4	19.0	104.5	18.7	103.1	96.9	22.6	+3.6	96.2	90.4	25.4	+6.4
22	CL	107.9	17.7	107.0	15.8	110.9	102.8	18.8	+1.1	105.4	97.7	18.7	+1.0
34	CH	103.4	20.4	96.2	22.7	101.4	98.1	20.8	+0.4	101.4	98.1	22.6	+2.2
25	CL	108.9	17.5	102.4	21.3	108.9	100.0	19.1	+1.6	106.6	97.9	20.0	+2.5
21	CL	116.9	13.6	116.3	13.9	113.3	96.9	17.0	+3.4	108.7	93.0	17.4	+3.8
31	CL	105.6	18.6	98.7	19.1	100.5	95.2	20.0	+1.4	103.1	97.6	21.2	+2.6
20	CL	106.5	17.4	103.6	18.5	104.9	98.5	19.7	+2.3	102.3	96.1	21.9	+4.5
28	CL	111.2	16.1	111.5	15.7	107.2	96.4	16.1	0.0	110.5	99.4	15.6	-0.5
53	CH	98.5	23.5	98.7	22.8	97.5	99.0	25.8	+2.3	96.1	97.6	25.4	+1.9

...CORD CONTROL SUMMARY

Revisions			
Symbol	Descriptions	Date	Approved

U. S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
KANSAS CITY, MISSOURI

Designed by:

Drawn by:

Checked by:

Submitted by:

US Army Corps of Engineers

BIG BULL CREEK, KANSAS
HILLSDALE LAKE
EMBANKMENT CRITERIA REPORT

RECORD CONTROL DATA - STAGE III
STANDARD COMPACTION TEST
LABORATORY VS. FIELD

Scale:

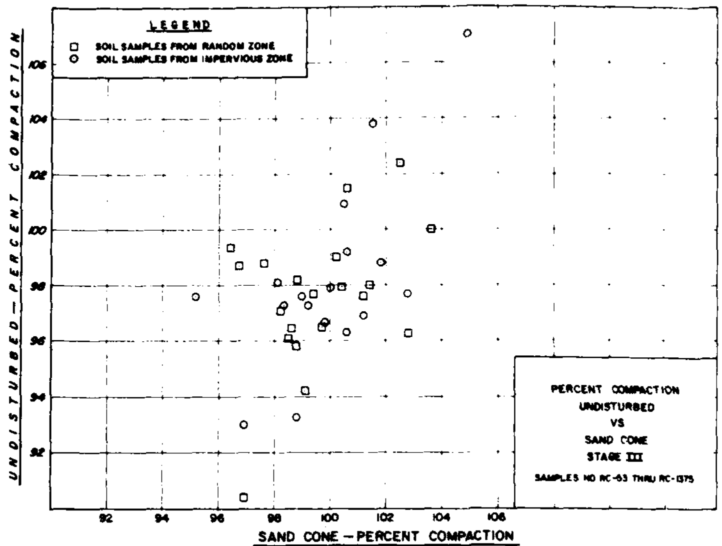
Date: SEPTEMBER 1984

Dwg. No.

Sheet number 2 of 5

File No. 0-15-1066

PLATE NO. 72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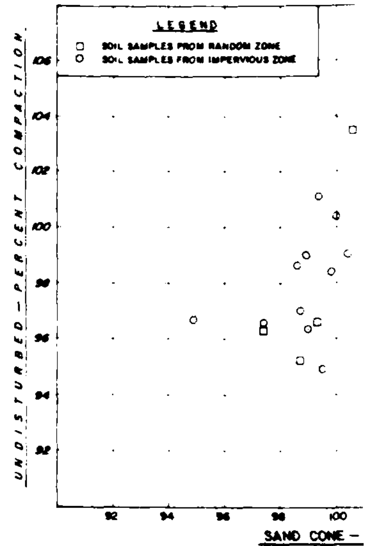
SOIL SAMPLES FROM RANDOM ZONE
SOIL SAMPLES FROM IMPERVIOUS ZONE
UNDISTURBED — PERCENT COMPACTION
SAND CONE — PERCENT COMPACTION
PERCENT COMPACTION
UNDISTURBED
VS
SAND CONE
STAGE III
SAMPLES NO RC-63 THRU RC-1375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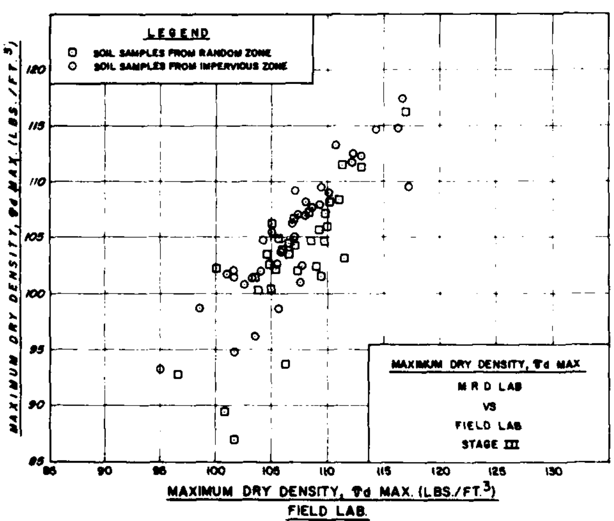
SOIL SAMPLES FROM RANDOM ZONE
SOIL SAMPLES FROM IMPERVIOUS ZONE
UNDISTURBED — PERCENT COMPACTION
SAND CONE —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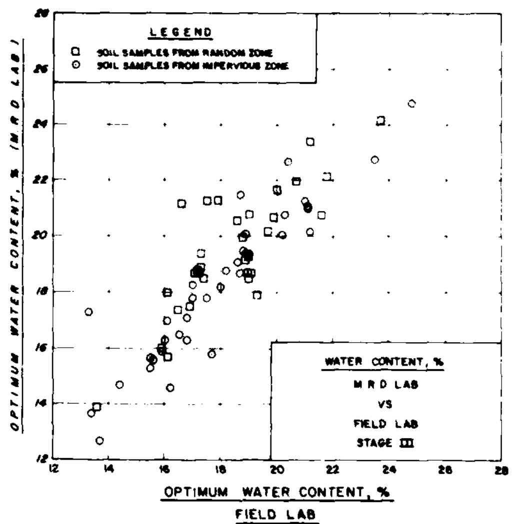
SOIL SAMPLES FROM RANDOM ZONE
SOIL SAMPLES FROM IMPERVIOUS ZONE
MAXIMUM DRY DENSITY, γd MAX. (LBS./FT.³)
MAXIMUM DRY DENSITY, γd MAX
M R D LAB
VS
FIELD LAB
STAGE III
MAXIMUM DRY DENSITY, γd MAX. (LBS./FT.³)
FIELD LAB.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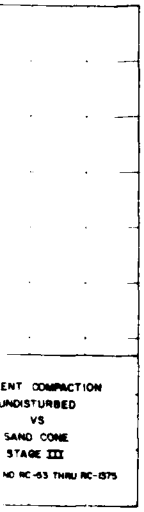
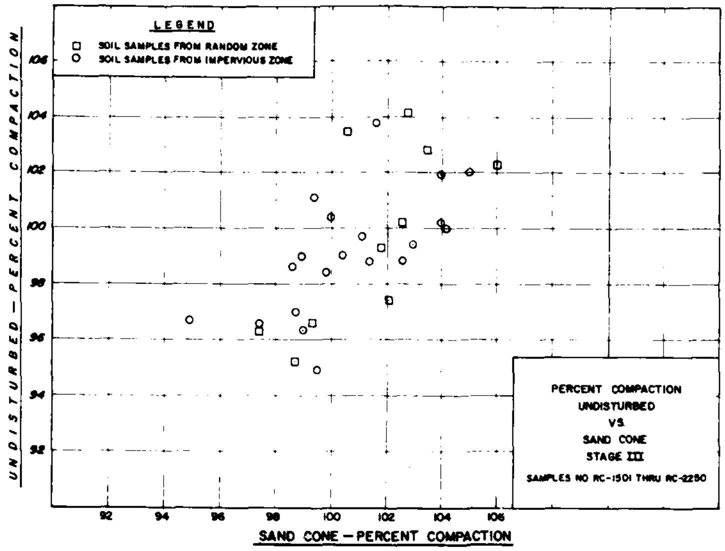
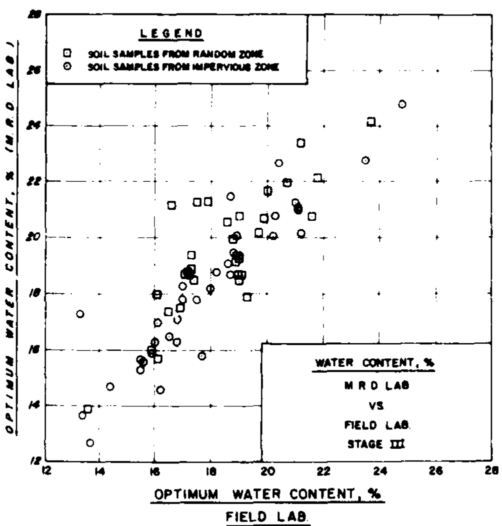
SOIL SAMPLES FROM RANDOM ZONE
SOIL SAMPLES FROM IMPERVIOUS ZONE
OPTIMUM WATER CONTENT, % (M R D LAB)
WATER CONTENT, %
M R D LAB
VS
FIELD LAB
STAGE III
OPTIMUM WATER CONTENT, %
FIELD LAB







Revisions			
Symbol	Descriptions	Date	Approved

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KANSAS CITY, MISSOURI

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US Army Corps of Engineers

BIG BULL CREEK, KANSAS
HILLSDALE LAKE
EMBANKMENT CRITERIA REPORT

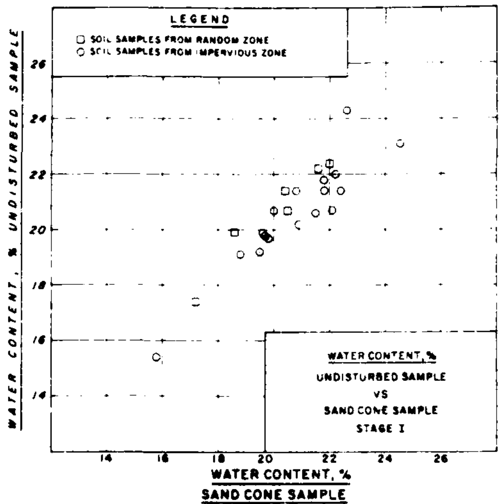
RECORD CONTROL TEST DATA — STAGE III

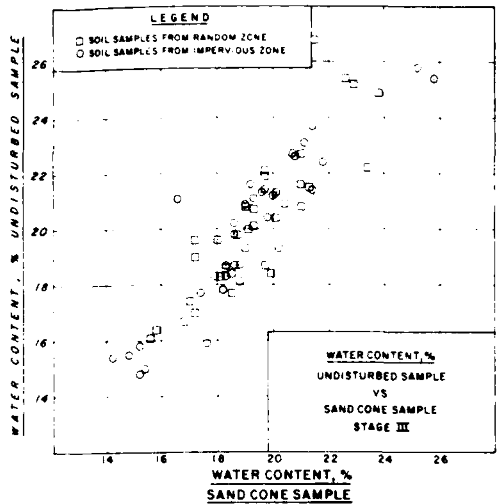
Scale: | Sheet number: 3 of 5 | Date: SEPTEMBER 1984 | Dwg No: | File No: 0-15-1067

PLATE NO 73

5 4 3 2

D





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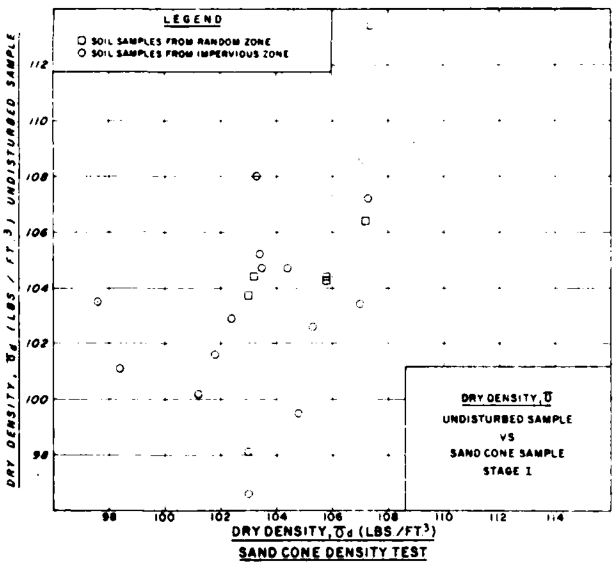

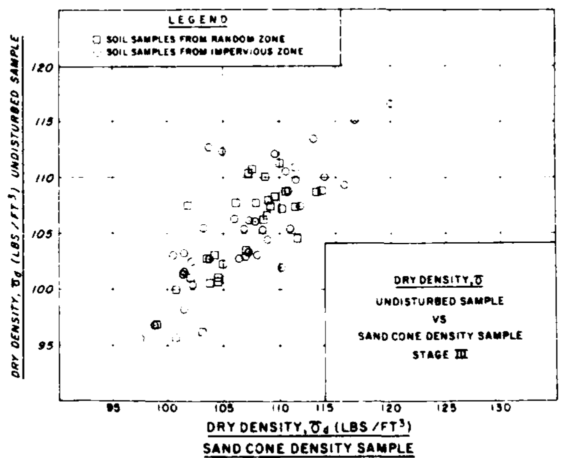

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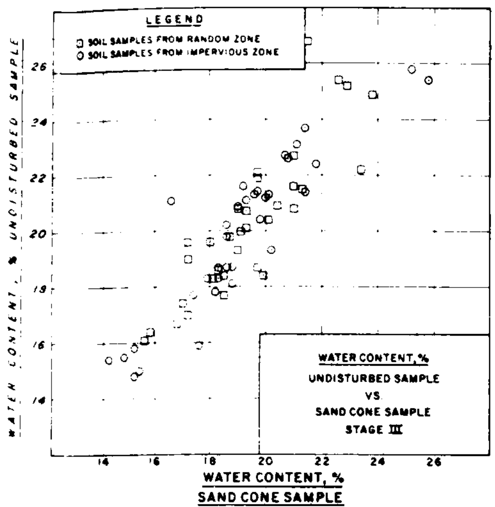

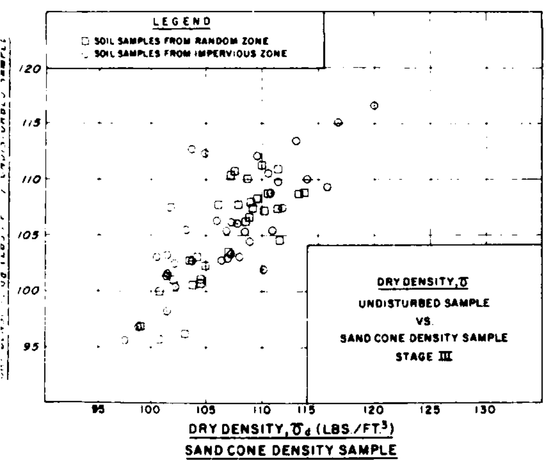

Revisions			
Symbol	Descriptions	Date	Approved

U. S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
KANSAS CITY, MISSOURI

BIG BULL CREEK, KANSAS
HILLSDALE LAKE
EMBANKMENT CRITERIA REPORT

RECORD CONTROL TEST DATA-STAGE I & III

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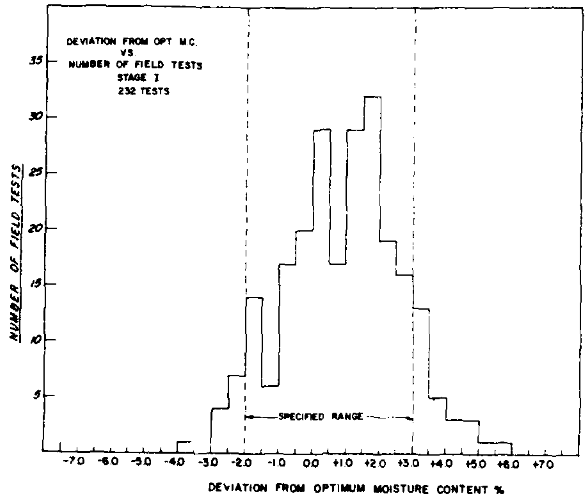
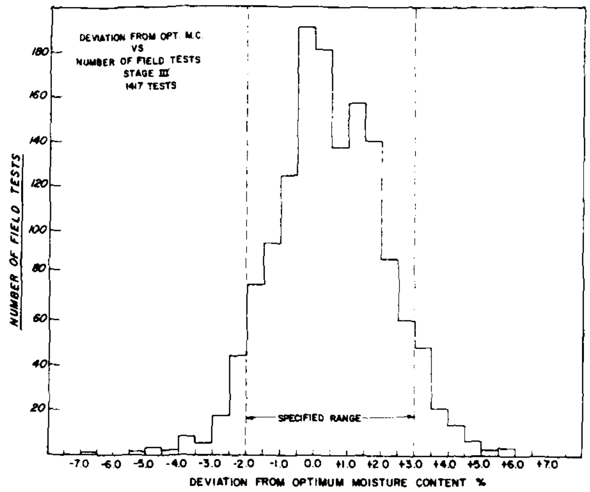
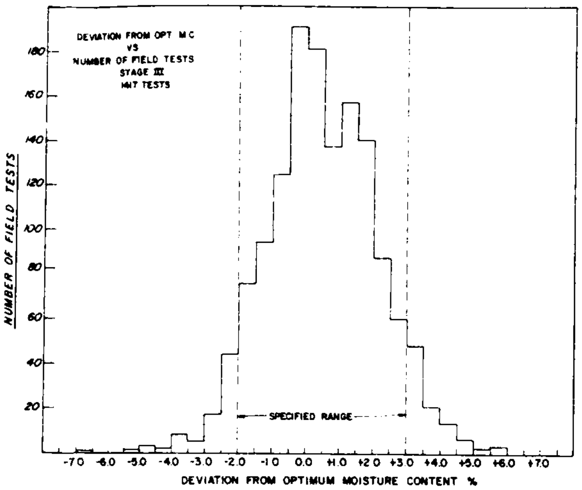
Checked by:	Scale: / Sheet number
Submitted by:	Date:
	Dwg. No. 4 of 5 / File No. 0-15-1068

PLATE NO. 74


DEVIATION FROM OPT. M.C.
VS
NUMBER OF FIELD TESTS
STAGE I
232 TESTS
NUMBER OF FIELD TESTS
SPECIFIED RANGE
DEVIATION FROM OPTIMUM MOISTURE CONTENT %


DEVIATION FROM OPT. M.C.
VS
NUMBER OF FIELD TESTS
STAGE III
1417 TESTS
NUMBER OF FIELD TESTS
SPECIFIED RANGE
DEVIATION FROM OPTIMUM MOISTURE CONTENT %



Revisions			
Symbol	Descriptions	Date	Approved

U S ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
KANSAS CITY, MISSOURI

Designed by:

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US Army Corps of Engineers

BIG BULL CREEK, KANSAS

HILLSDALE LAKE

EMBANKMENT CRITERIA REPORT

RECORD CONTROL DATA - STAGE I & III
STANDARD COMPACTION TEST
LABORATORY VS FIELD

Scale:

Date: SEPTEMBER 1984

Dwg No:

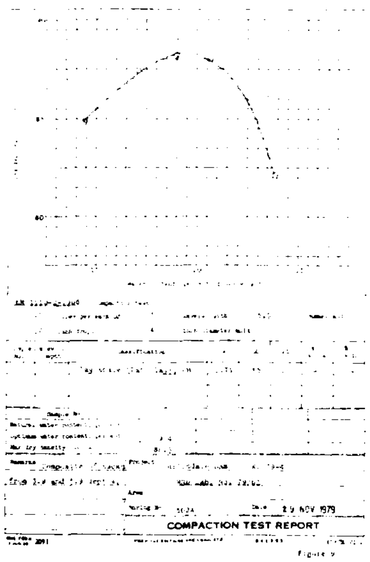
Sheet number: 5 of 5

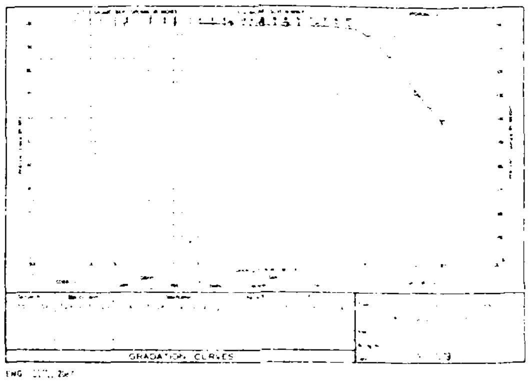
File No: 0-15-1069

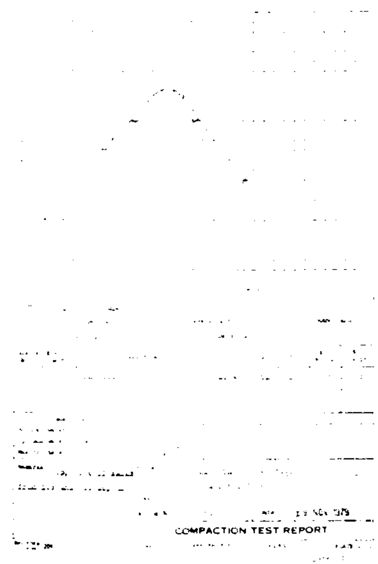
PLATE NO 75

5 4 3 2

D







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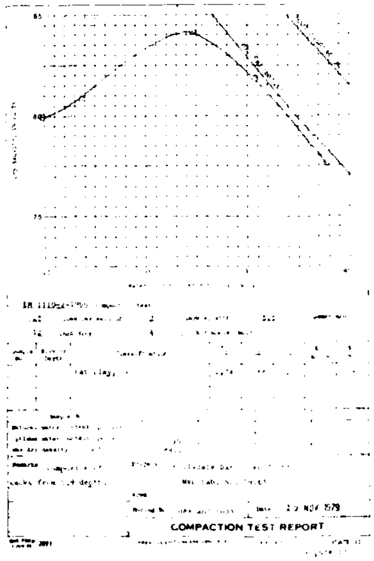

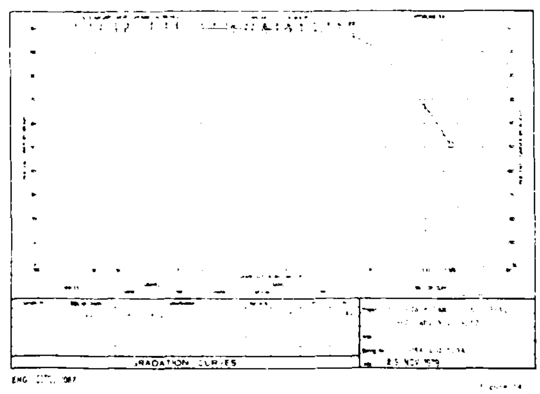

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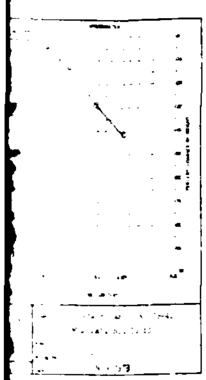
5 4 3 2



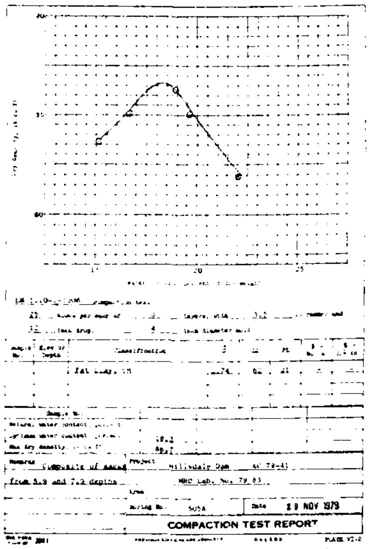


Figure 11

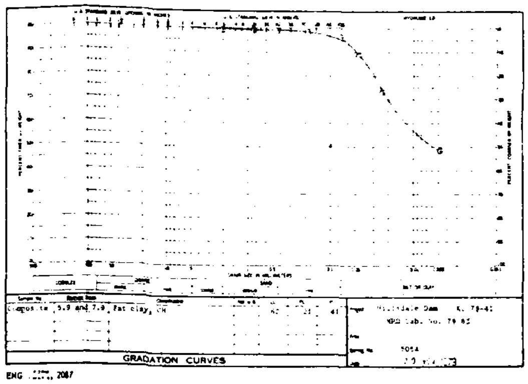


Figure 12

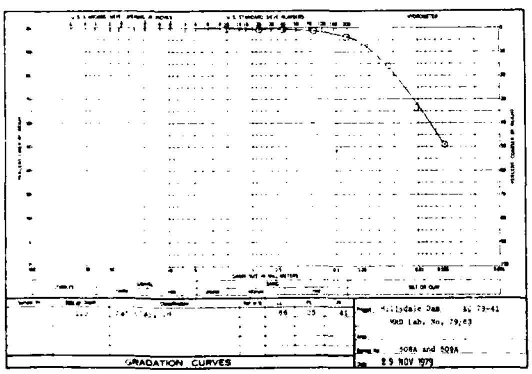


Figure 14

Revisions			
Symbol	Descriptions	Date	Approved

U. S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
KANSAS CITY, MISSOURI

Designed by:
Drawn by:
Checked by:
Submitted by:

BIG BULL CREEK, KANSAS
HILLSDALE LAKE
EMBANKMENT CRITERIA REPORT

BORROW AREA COMPACTION TEST RESULTS

Scale:
Sheet number
Date: SEPTEMBER 1984
Dwg. No.
File No. 0-15-1070

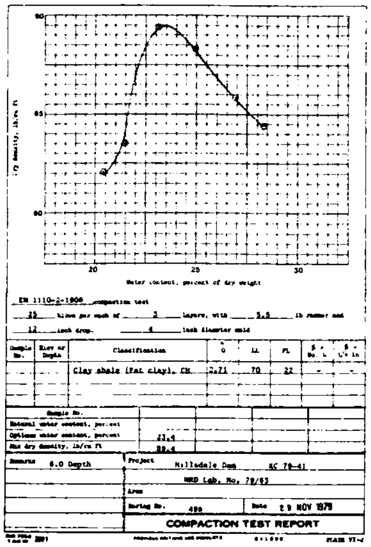


Figure 1

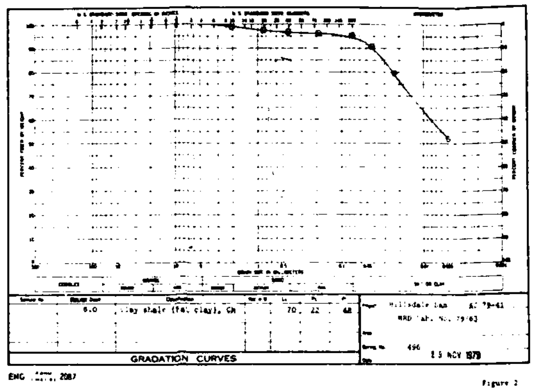
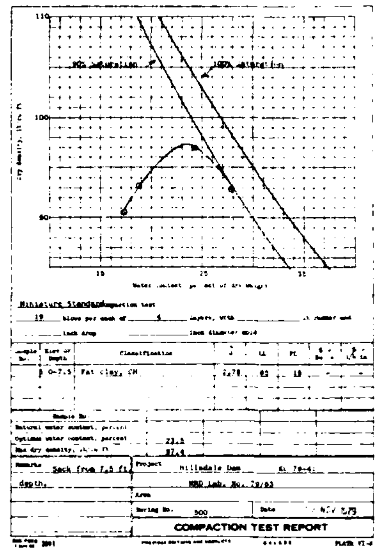


Figure 2



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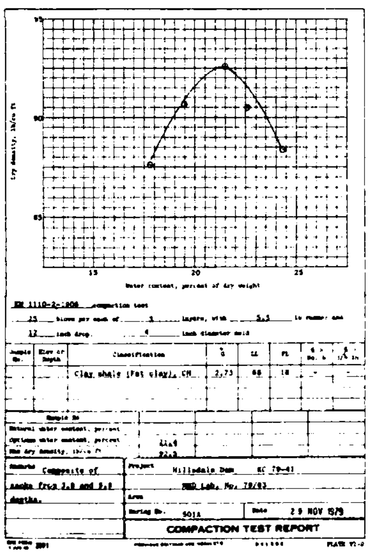


Figure 5

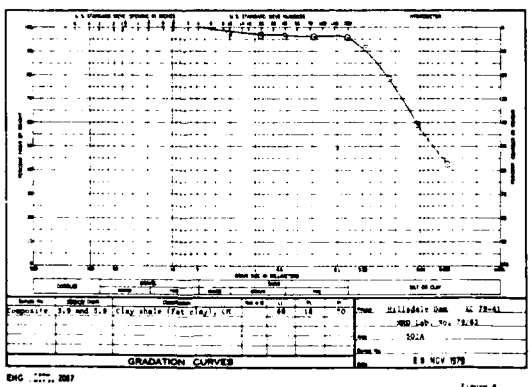


Figure 6

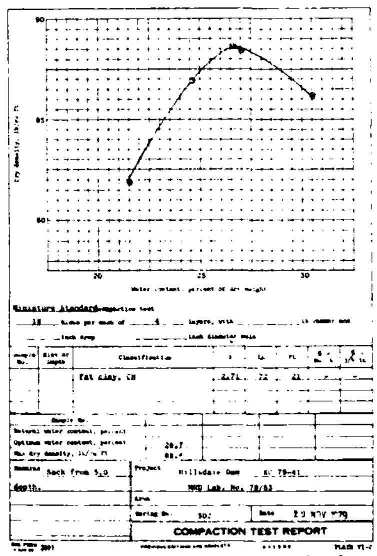
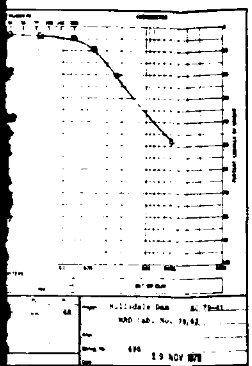


Figure 7



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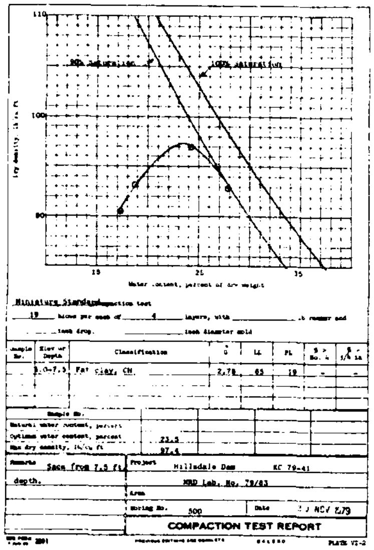

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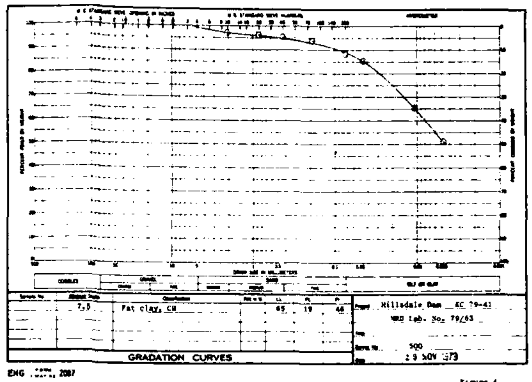

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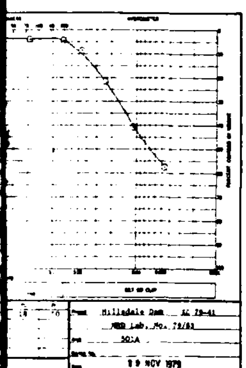


Figure 6

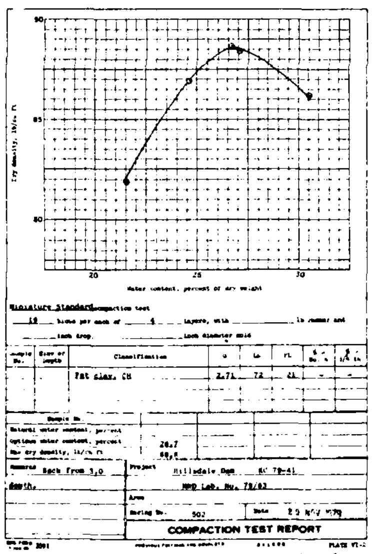


Figure 7

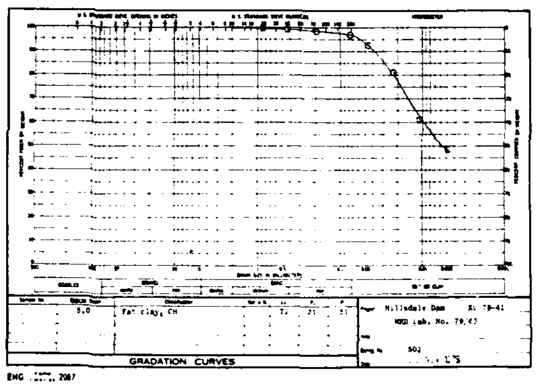


Figure 5

Revisions			
Symbol	Descriptions	Date	Approved

U. S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
KANSAS CITY, MISSOURI

Designed by:

Drawn by:

Checked by:

Submitted by:

US Army Corps of Engineers

BIG BULL CREEK, KANSAS
HILLSDALE LAKE
EMBANKMENT CRITERIA REPORT

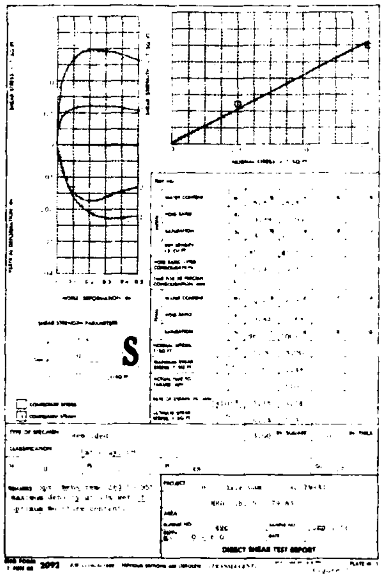
BORROW AREA COMPACTION TEST RESULTS

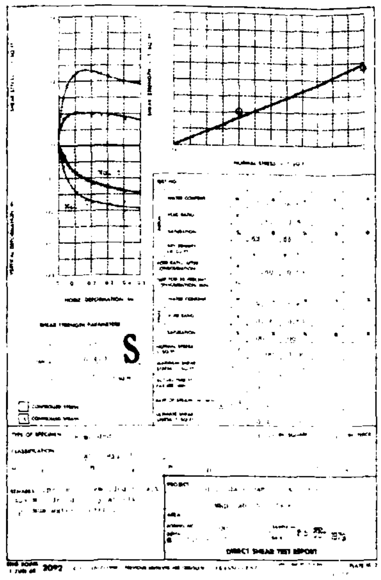
Scale:
Sheet number:
Date: SEPTEMBER 1984
Dwg. No.
File No. 0-15-1071

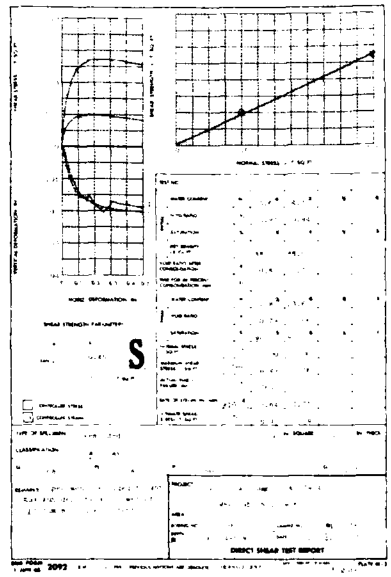
PLATE NO 77

5 4 3 2

D







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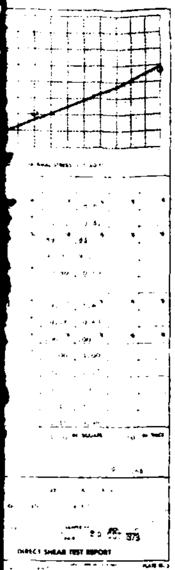

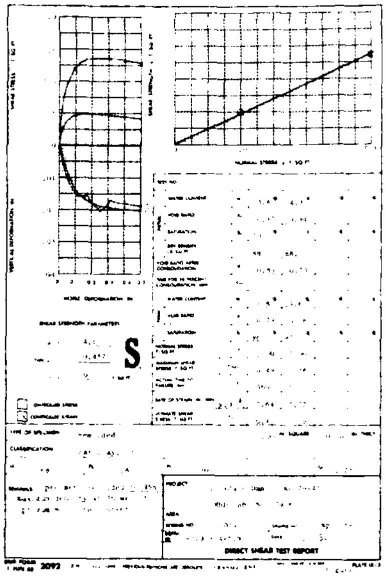

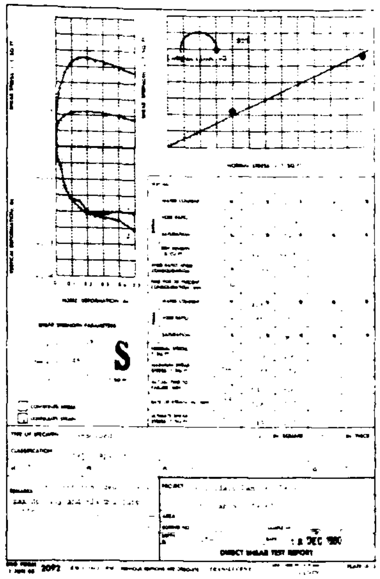

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Revisions			
Symbol	Descriptions	Date	Approved

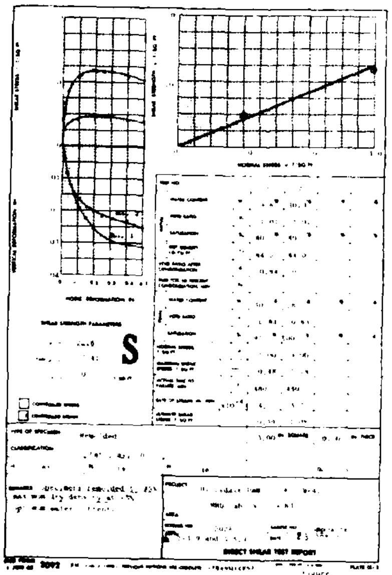
U S ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
KANSAS CITY, MISSOURI

Designed by:	US Army Corps of Engineers — BIG BULL CREEK, KANSAS — HILLSDALE LAKE — EMBANKMENT CRITERIA REPORT
Drawn by:	BORROW AREA REMOLDED "S" TESTS
Checked by:	Scale: / Sheet Number:
Submitted by:	Date: / Dwg No.: / 1 of 2 / File No. 0-15-1072

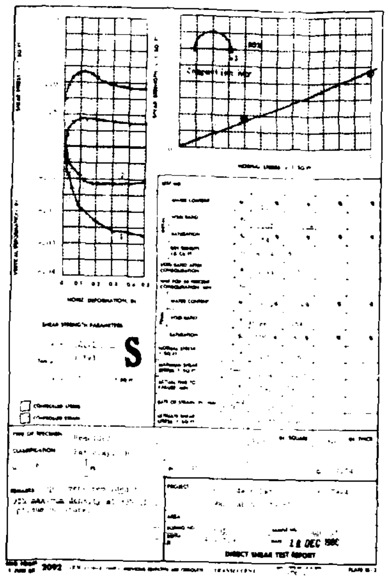
3 2 1 PLATE NO. 78

5 4 3

D



S
DIRECT SHEAR TEST REPORT



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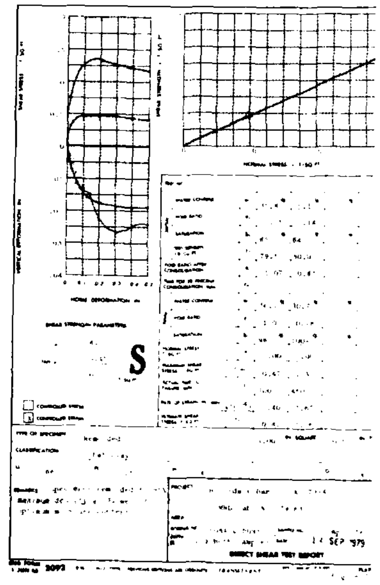
DIRECT SHEAR TEST REPORT



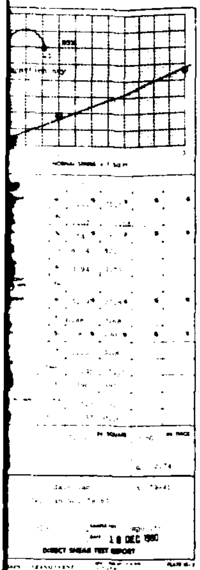
S
DIRECT SHEAR TEST REPORT

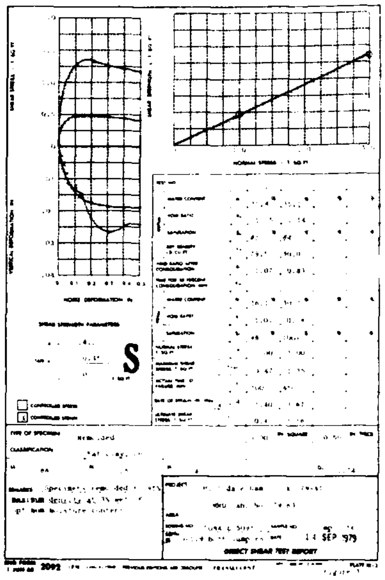
C

B

A

5 4 3





Revisions			
Symbol	Descriptions	Date	Approved

U. S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
KANSAS CITY, MISSOURI

US Army Corps of Engineers

BIG BULL CREEK, KANSAS
HILLSDALE LAKE
EMBANKMENT CRITERIA REPORT

BORROW AREA REMOLDED "S" TESTS

Designed by:	Scale:	Sheet number: 1 of 2	
Drawn by:	Date:		
Checked by:	Dwg. No.:		File No. 0-15-1073
Submitted by:			

PLATE NO 79

2

5 4 3 2

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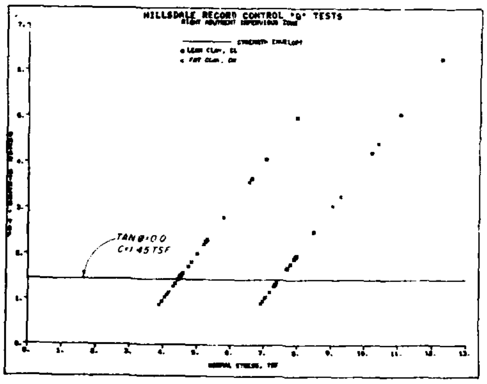

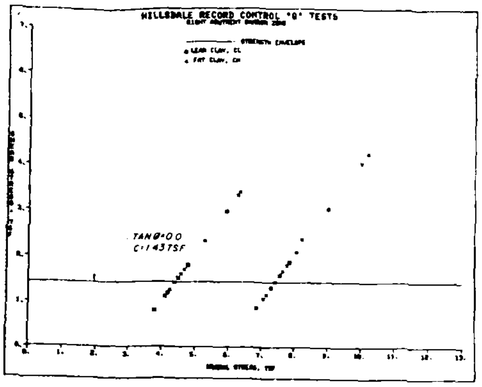

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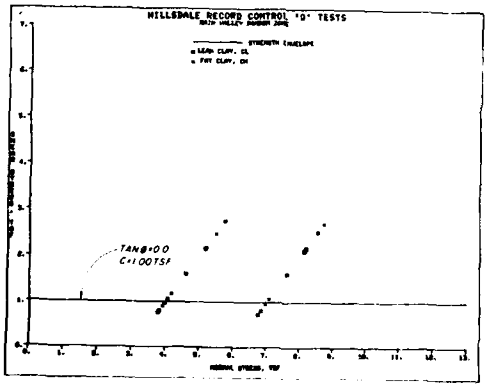

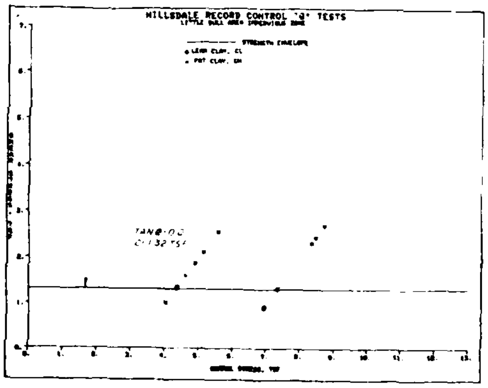

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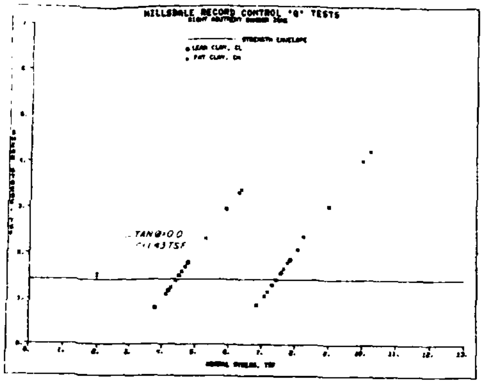
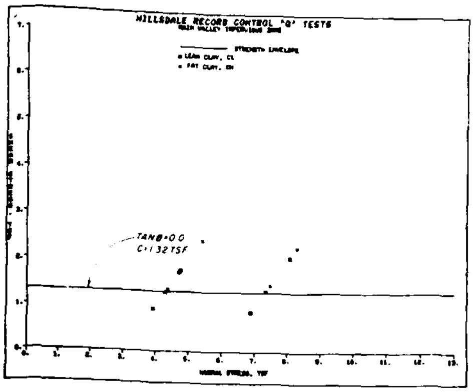
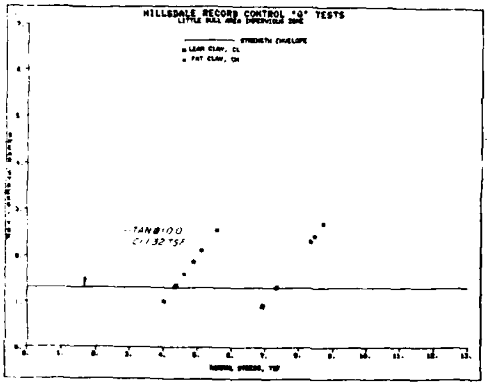
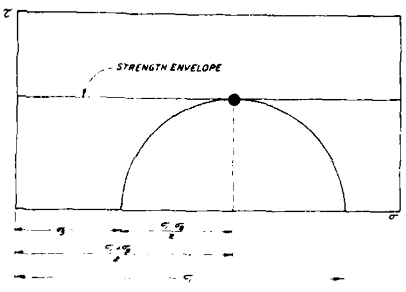








MOHR'S DIAGRAM

Symbol	Revisions Descriptions	Date	Approved

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
KANSAS CITY, MISSOURI

Designed by

Drawn by

Checked by

Submitted by

US Army Corps of Engineers

BIG BULL CREEK, KANSAS
HILLSDALE LAKE
EMBANKMENT CRITERIA REPORT

RECORD CONTROL "Q" TEST SUMMARY

Scale | Sheet number

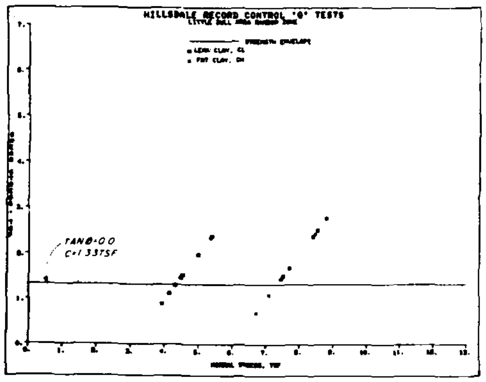
Date SEPTEMBER 1984

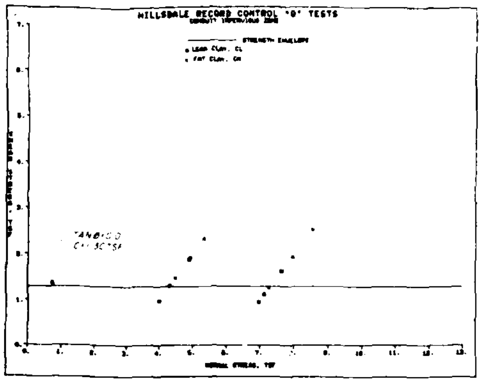
Dwg No. 1 of 2 | File No. 0-15-1074

PLATE NO. 80

5 4 3 2

D





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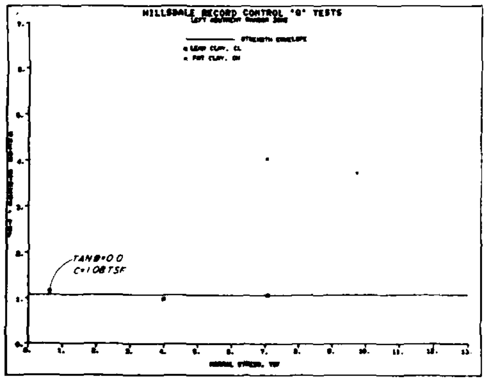

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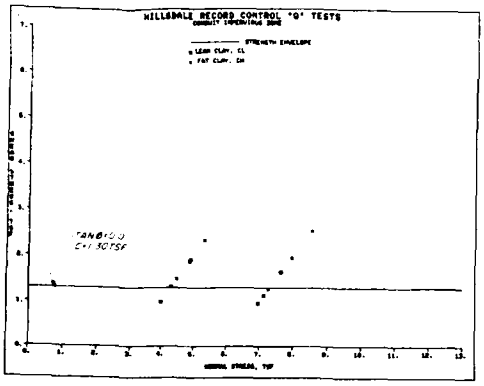

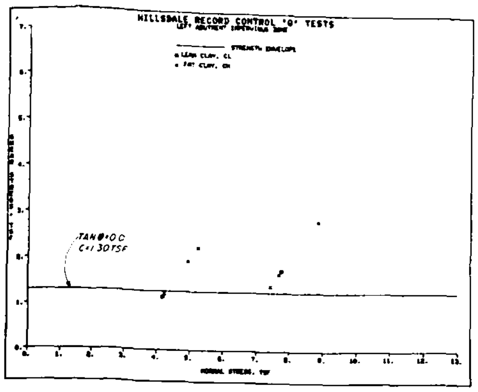

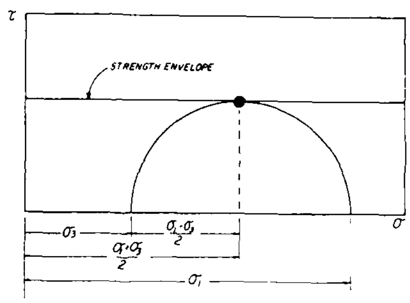

MOHR'S DIAGRAM

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
KANSAS CITY, MISSOURI

US Army Corps of Engineers

BIG BULL CREEK, KANSAS
HILLSDALE LAKE
EMBANKMENT CRITERIA REPORT

RECORD CONTROL "Q" TEST SUMMARY

SEPTEMBER 1984

2 of 2

0-15-1075

PLATE NO. 81

5 4 3

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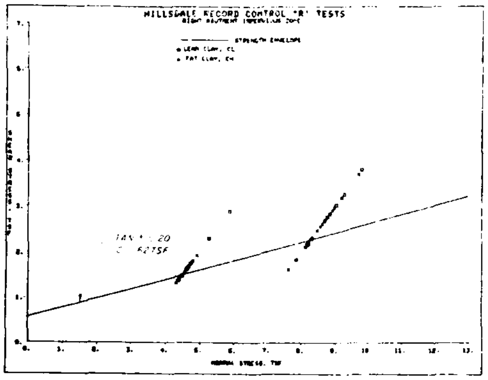
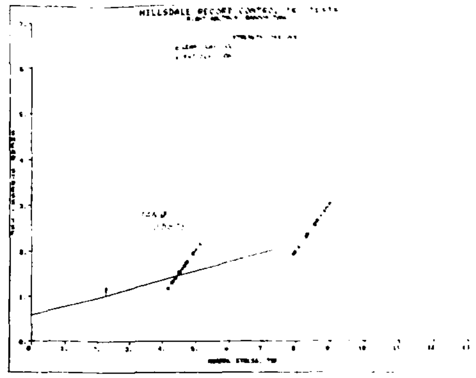
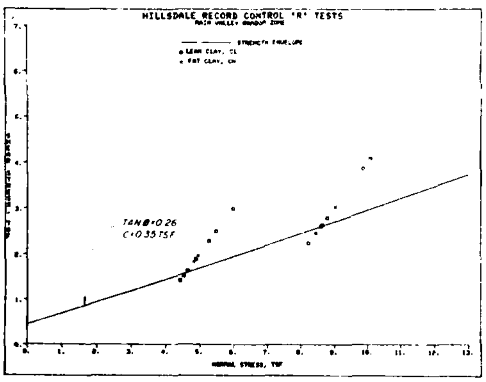


HILLSDALE RECORD CONTROL "R" TESTS
STRENGTH ENVELOPE
0. 1. 2. 3. 4. 5. 6. 7. 8. 9. 10 11. 12. 13.

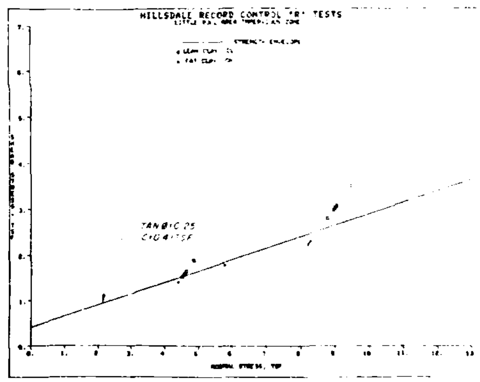


HILLSDALE RECORD CONTROL "R" TESTS

C



HILLSDALE RECORD CONTROL "R" TESTS
STRENGTH ENVELOPE
LEAN CLAY, CL
FAT CLAY, CH
TAN Ø=0.26
C=0.35 TSF
0. 1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12. 13.
NORMAL STRESS, TSF



HILLSDALE RECORD CONTROL "R" TESTS

B

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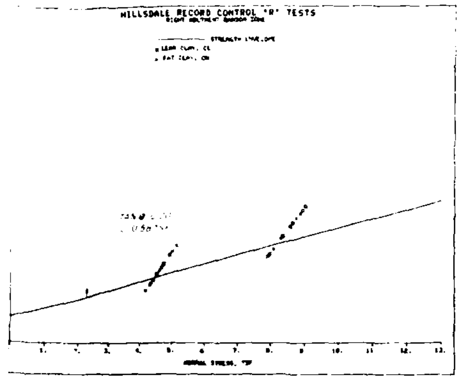
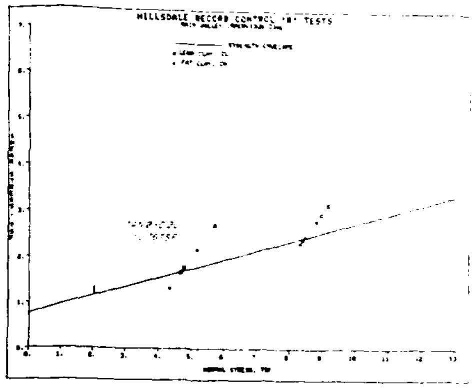
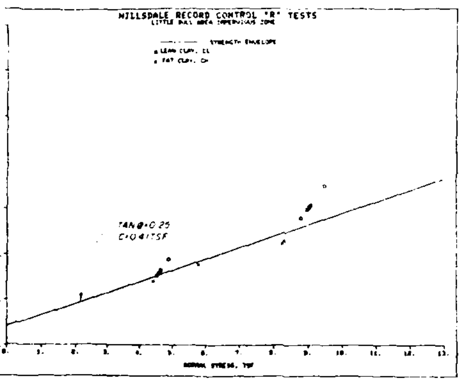
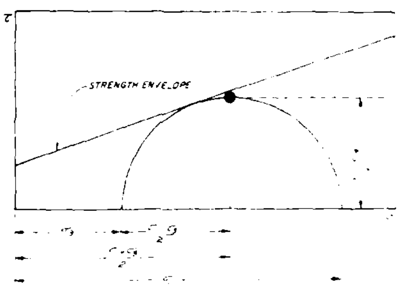
5 4 3









MOHR'S DIAGRAM

BIG BULL CREEK, KANSAS

HILLSDALE LAKE

EMBANKMENT CRITERIA REPORT

RECORD CONTROL "R" TEST SUMMARY

SEPTEMBER 1984

1 of 4 File No 0-15-1076

PLATE NO 82

5 4 3 2

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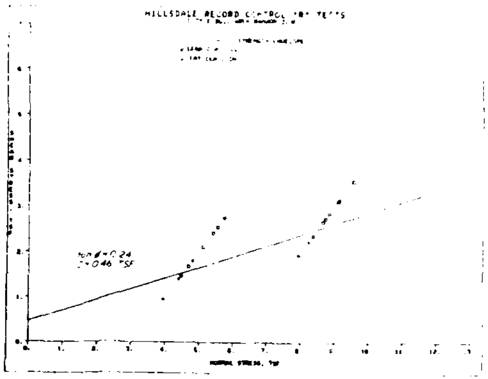

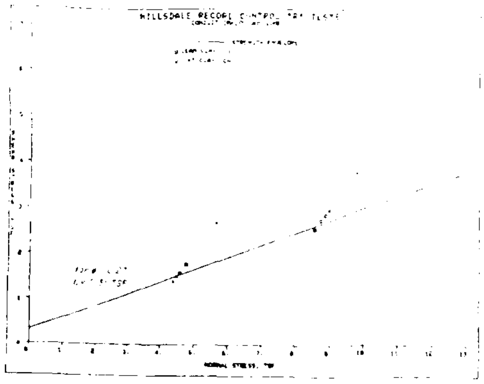

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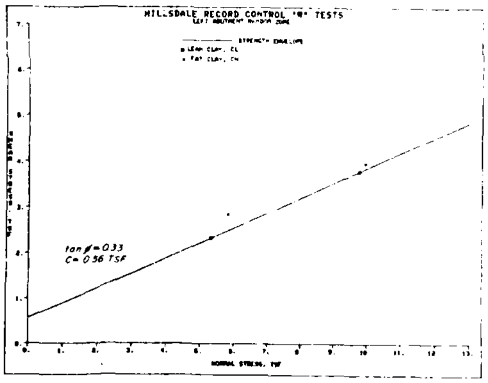

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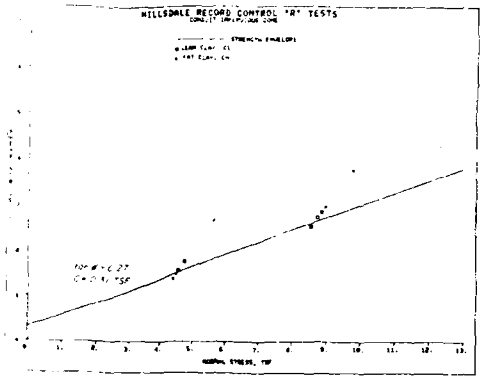
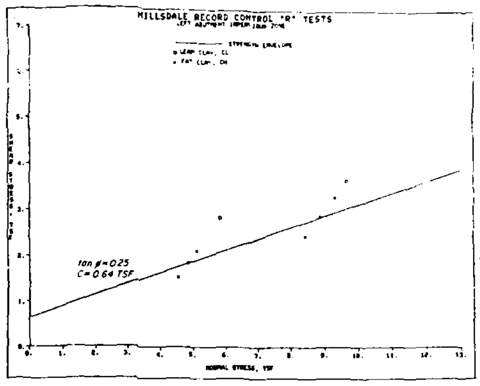
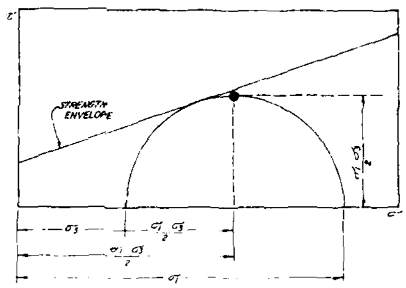






MOHR'S DIAGRAM

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
KANSAS CITY, MISSOURI

BIG BULL CREEK, KANSAS
HILLSDALE LAKE
EMBANKMENT CRITERIA REPORT

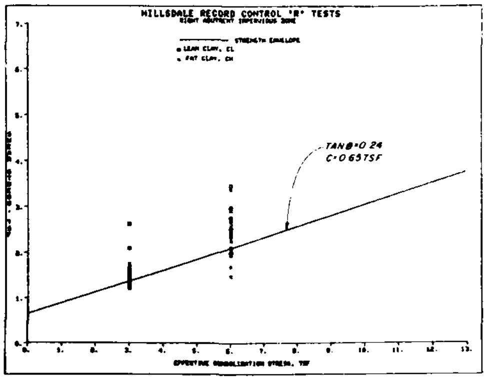
RECORD CONTROL "R" TEST SUMMARY

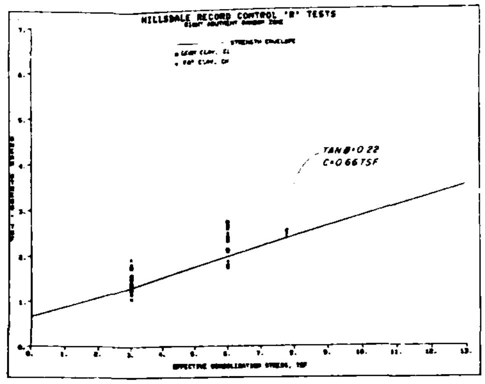
Date: SEPTEMBER 1984

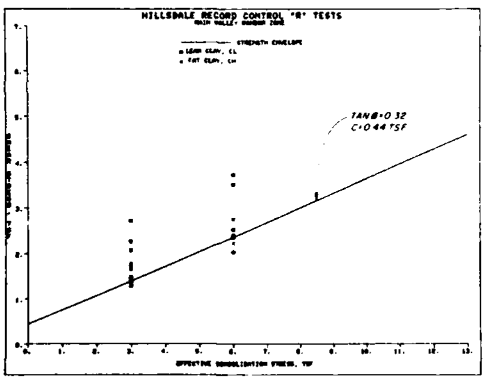
2 of 4

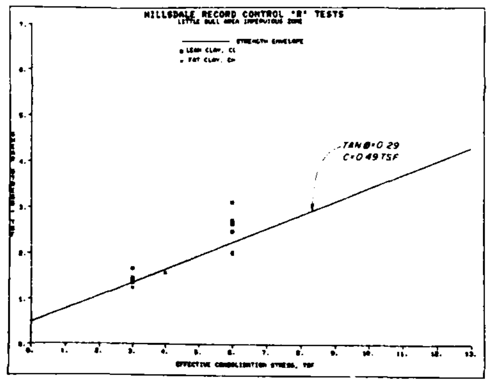
File No. 0-15-1077

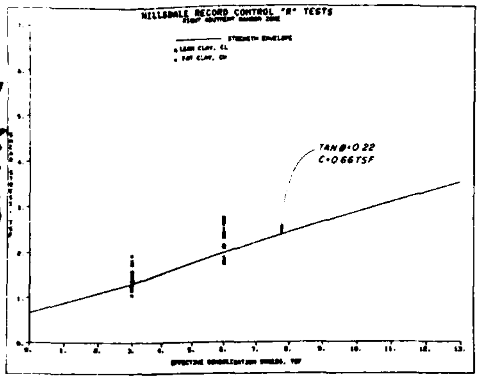
PLATE NO. 83

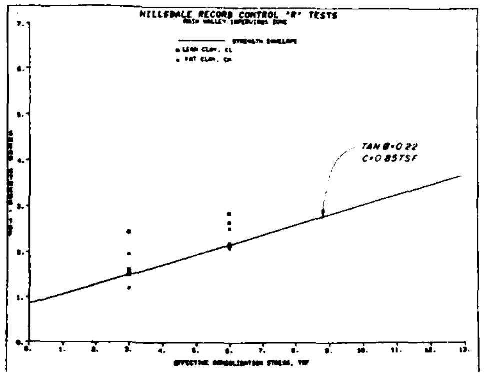

HILLSDALE RECORD CONTROL 'R' TESTS
STRENGTH ENVELOPE
LEAN CLAY, CL
FAT CLAY, CH
TANØ=0.24
C=0.65TSF
EFFECTIVE CONSOLIDATION STRESS, TSF

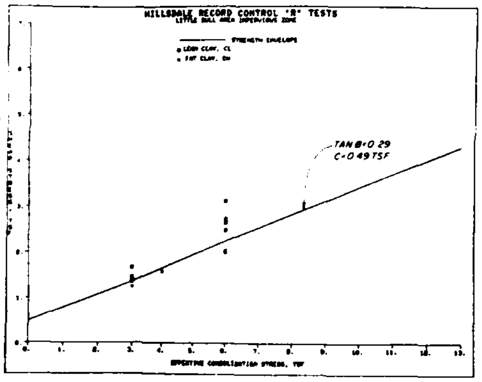

HILLSDALE RECORD CONTROL 'R' TESTS
STRENGTH ENVELOPE
LEAN CLAY, CL
FAT CLAY, CH
TANØ=0.22
C=0.66TSF
EFFECTIVE CONSOLIDATION STRESS, TSF

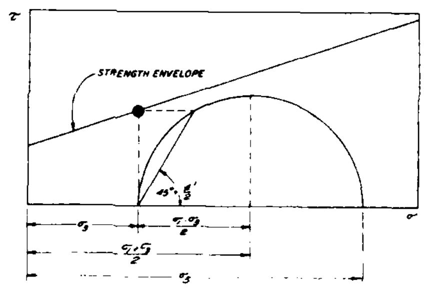

HILLSDALE RECORD CONTROL 'R' TESTS
STRENGTH ENVELOPE
LEAN CLAY, CL
FAT CLAY, CH
TANØ=0.32
C=0.44TSF
EFFECTIVE CONSOLIDATION STRESS, TSF


HILLSDALE RECORD CONTROL 'R' TESTS
STRENGTH ENVELOPE
LEAN CLAY, CL
FAT CLAY, CH
TANØ=0.29
C=0.49TSF
EFFECTIVE CONSOLIDATION STRESS, TSF









MOHR'S DIAGRAM

Symbol	Revisions Descriptions	Date	Approved

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
KANSAS CITY, MISSOURI

Designed by | Drawn by | Checked by | Submitted by

US Army Corps of Engineers

BIG BULL CREEK, KANSAS
HILLSDALE LAKE
EMBANKMENT CRITERIA REPORT

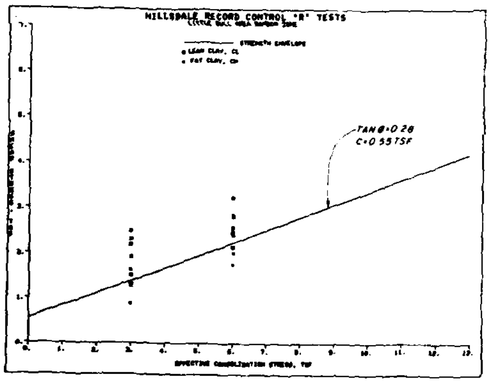
RECORD CONTROL "R" TEST SUMMARY

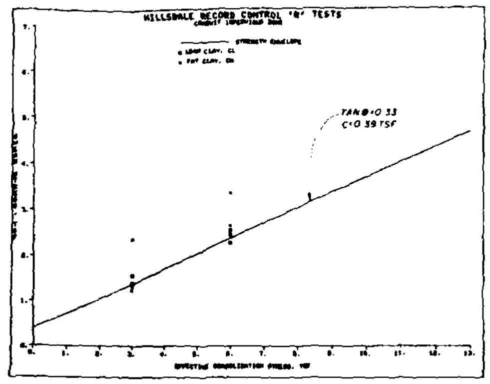
Scale | Sheet number

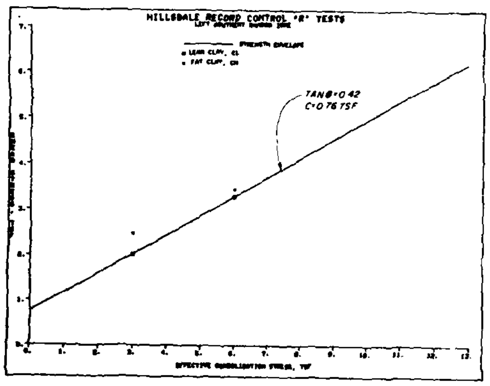
Date SEPTEMBER 1984

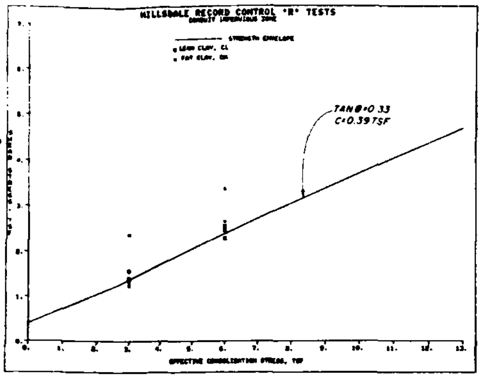
Dwg No. 3 of 4 File No. 0-15-1078

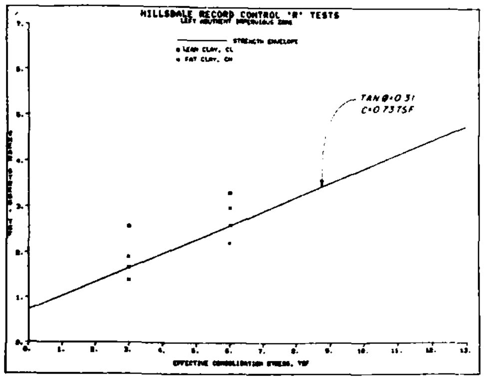
PLATE NO. 84

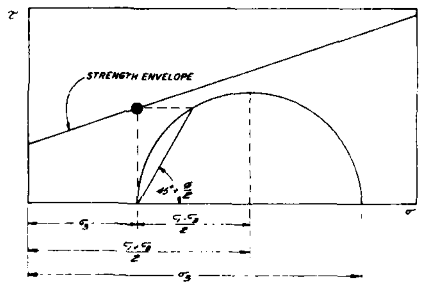

HILLSDALE RECORD CONTROL 'R' TESTS
TANθ=0 28
C=0 55TSF


HILLSDALE RECORD CONTROL 'R' TESTS
TANθ=0 33
C=0 39TSF


HILLSDALE RECORD CONTROL 'R' TESTS
TANθ=0 42
C=0 76TSF







MOHR'S DIAGRAM

Revisions			
Symbol	Descriptions	Date	Approved

U. S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
KANSAS CITY, MISSOURI

Designed by
Drawn by
Checked by
Submitted by

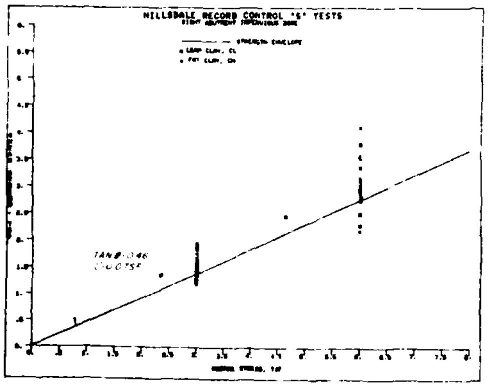
US Army Corps of Engineers

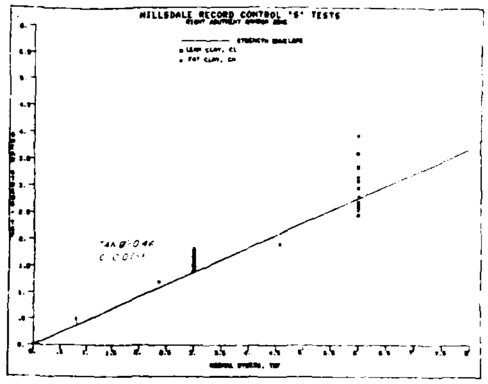
BIG BULL CREEK, KANSAS
HILLSDALE LAKE
EMBANKMENT CRITERIA REPORT

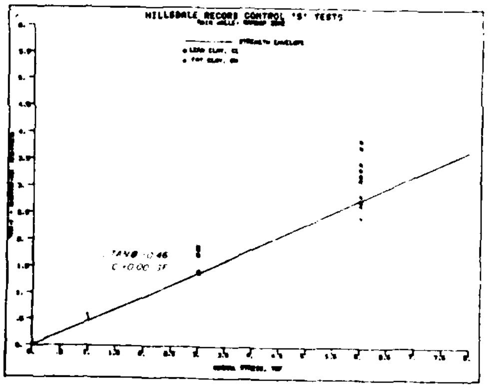
RECORD CONTROL "R" TEST SUMMARY

Scale
Sheet number
Date SEPTEMBER 1984
Dwg No. 4 of 4
File No. 0-15-1079

PLATE NO. 85


HILLSDALE RECORD CONTROL "S" TESTS


HILLSDALE RECORD CONTROL "S" TESTS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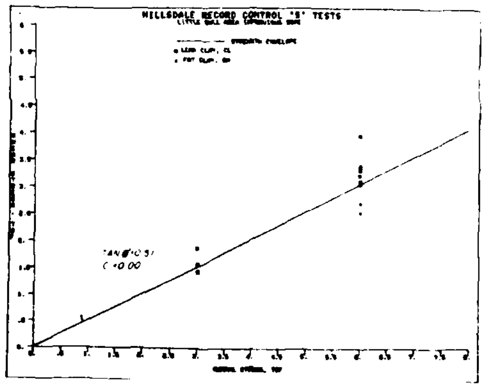
HILLSDALE RECORD CONTROL "S" TESTS

3 2 1

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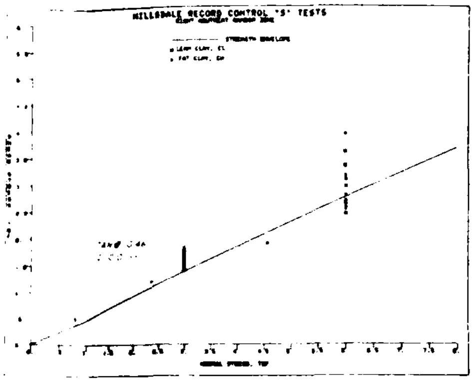

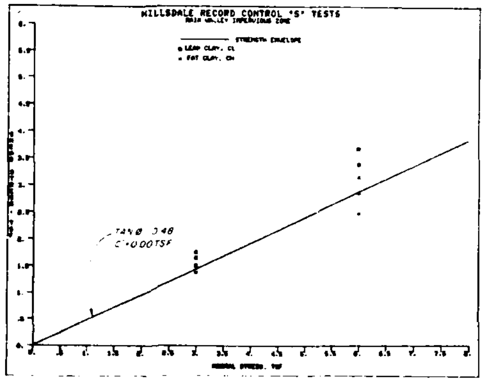

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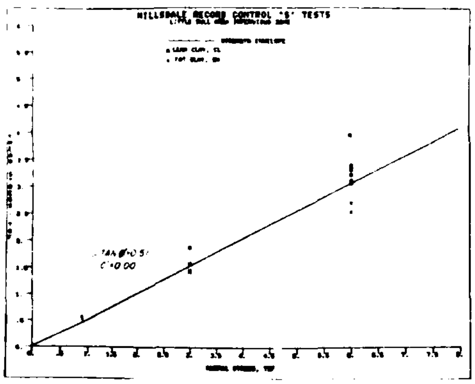

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Revisions			
Symbol	Descriptions	Date	Approved

U. S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
KANSAS CITY, MISSOURI

Designed by	US Army Corps of Engineers — BIG BULL CREEK, KANSAS — HILLSDALE LAKE — EMBANKMENT CRITERIA REPORT
Drawn by	RECORD CONTROL "S" TEST SUMMARY
Checked by	Scale / Sheet number
Submitted by	Date SEPTEMBER 1984
	Dwg No. — 1 of 2 — File No. 0-15-1080

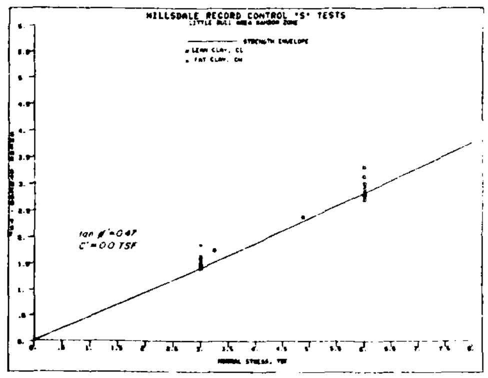
A

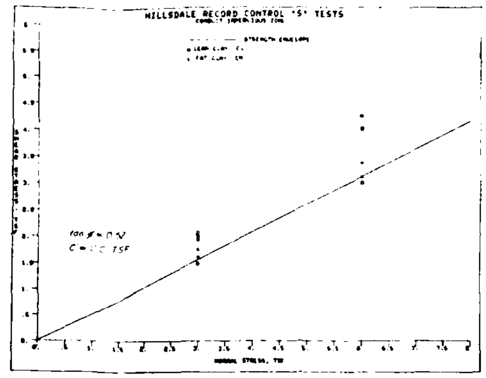
3 2 1

PLATE NO. 86

5 4 3 2

D





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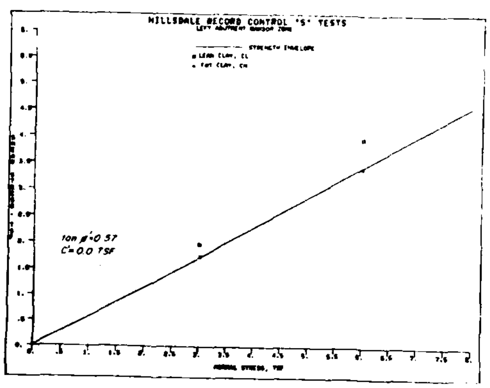
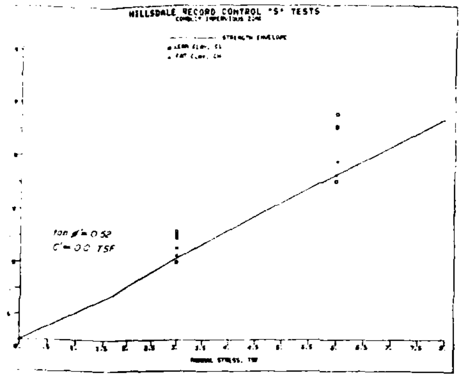
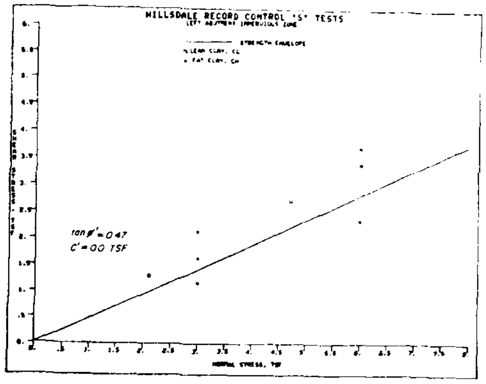


B

A

5 4 3 2





Symbol	Descriptions	Date	Approved

Revisions

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
KANSAS CITY, MISSOURI

Designed by

Drawn by

Checked by

Submitted by

US Army Corps of Engineers

BIG BULL CREEK, KANSAS
HILLSDALE LAKE
EMBANKMENT CRITERIA REPORT

RECORD CONTROL "S" TEST SUMMARY

Scale

Date SEPTEMBER 1984

Dwg No.

Sheet number 2 of 2

File No. 0-15-1081

PLATE NO. 87

FG

DEPARTMENT OF THE ARMY
MISSOURI RIVER DIVISION, CORPS OF ENGINEERS
DIVISION LABORATORY
OMAHA, NEBRASKA 68102

MRD Lab. No. [illegible]

[illegible] DEC 198[illegible]

Subject: Pinhole Dispersion, Double Hydrometer, and Crumb Tests and Chemical Analysis for Dissolved Salts

Project: Hillsdale Lake

Intended Use

Source of Material: Samples obtained from spillway slope

Submitted by: Chief, Engineering Division, Kansas City District

Date Sampled: ______ Date Received: [illegible] October 198[illegible]

Method of Test or Specification: EM-1110-2-1906

References:
a. Kansas City Request No. [illegible] 83-7 dated [illegible] Oct 8[illegible]
b. Sherard, Dunnigan, and Decker, "Identification and Nature of Dispersive Soils", Journal of the Geotechnical Engineering Division, ASCE, Vol. 102, No. GT4, Apr 76.
c. Sherard, Dunnigan, Decker, and Steele, "Pinhole Test for Identifying Dispersive Soils", Journal of The Geotechnical Engineering Division, ASCE, Vol. [illegible], No. [illegible], Jan 76.

Subject testing has been conducted in accordance with the above method and references. Results are presented in Tables 1 and 2 and Figures 1 through 3. All tests run indicate that both samples were non-dispersive, except the soluble salts test run on Sample No. 2. Since the soil pore water correlation has only about 85 percent reliance in predicting dispersive performance, it is felt that the other tests are sufficient to consider the material non-dispersive.

TABLE - 1
(Material: Sample No. 2)

1. Crumb test results: Non-dispersive.

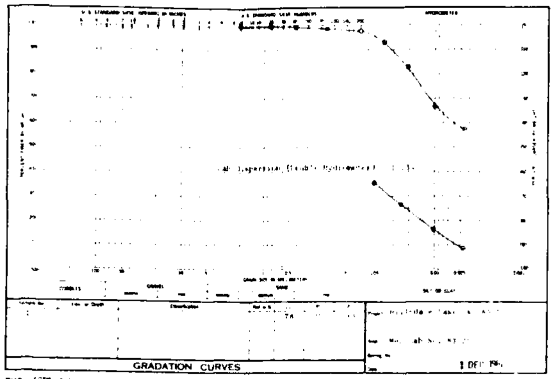
2. Soluble salts in pore water:

	Soluble Salts					
	Na	K	Ca	Mg	TDS	%Na
Filtrate from 50g dry soil and 250ml deionized water (meq/l)	2.1[illegible]	[illegible]	.66	[illegible]	[illegible]	6[illegible]
Concentration of actual pore water of soil at at liquid limit (meq/l)	16.3[illegible]	.31	5.[illegible]	[illegible]	2[illegible]	6[illegible]

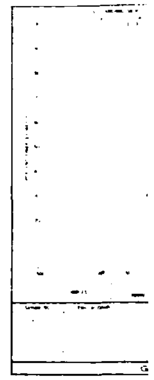
Submitted by

R. [illegible]
Director, MRD Laboratory

MRD FORM 119 MAY 70 EDITION OF FEB 67 IS OBSOLETE.



ENG FORM 2087



ENG FORM 2087

Project: Hillsdale Lake KC 83-7 MRD Lab. No.: 83-[illegible]

Pinhole Dispersion Test Results

Sample	Depth	Head, Inches	Test Time For Given Head, Minutes	Flow Through Specimen, ml/sec	Color of Flow at End of Test	Hole Size After Test, Needle Dia.	Classification
#1 (Tan)	-	40	[illegible]	[illegible]	Clear	No erosion	ND-1
#1 (Lighter)	-	15	[illegible]	[illegible]	Clear	[illegible]	ND-[illegible]
#2 (Undisturbed)	-	40	[illegible]	2.8	Clear	No erosion	ND-1
#2 (Remolded)	-	40	[illegible]	3.8	Traces of small particles	[illegible]	ND-1

Table [illegible]

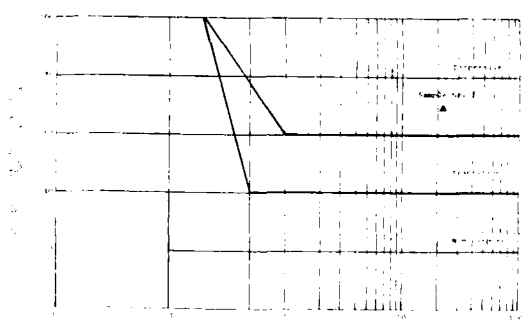


Figure [illegible]

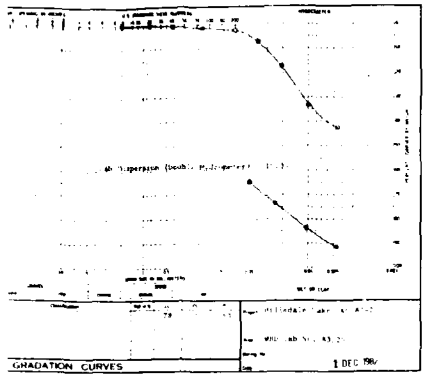


Figure 1

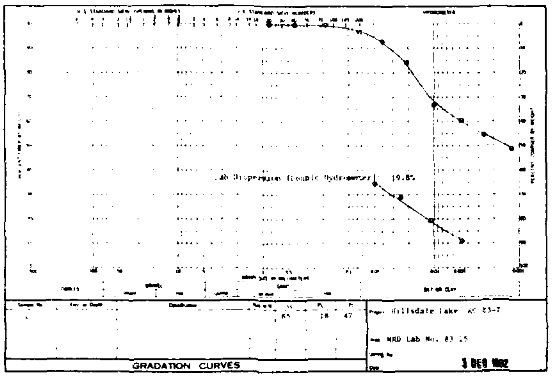


Figure 2

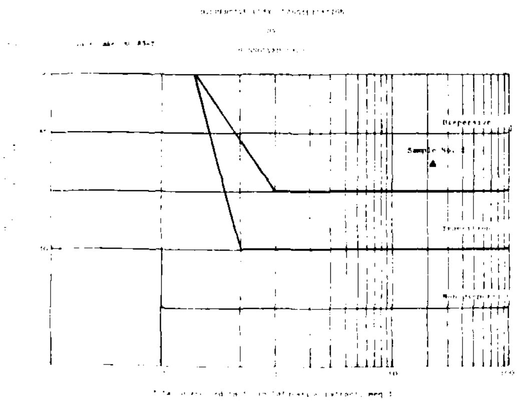


Figure 3

Revisions

Symbol	Descriptions	Date	Approved

U. S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
KANSAS CITY, MISSOURI

Designed by

Drawn by

Checked by

Submitted by

US Army Corps of Engineers

BIG BULL CREEK, KANSAS
HILLSDALE LAKE
EMBANKMENT CRITERIA REPORT

DISPERSION TEST RESULTS

Scale

Date SEPTEMBER 1984

Sheet number 1 of 2

File No. 0-15-1146

PLATE NO 151A

2

5 4 3 2

D

DEPARTMENT OF THE ARMY
MISSOURI RIVER DIVISION, CORPS OF ENGINEERS
DIVISION LABORATORY
OMAHA, NEBRASKA

1 8 JUL 1984

Subject: [illegible]

Project: [illegible]

Source of Material: [illegible]

Submitted by: [illegible]

Date Sampled [illegible] Date Received [illegible]

Method of Test or Specification [illegible]

References: [illegible]

[illegible] The November and May samples [illegible] respectively [illegible] distilled water was added [illegible] moisture [illegible] analysis of the pore water [illegible] lime was added to the May sample [illegible] test results indicate a nondispersive [illegible] 1, 2, and 3 and Figures 1 through [illegible]

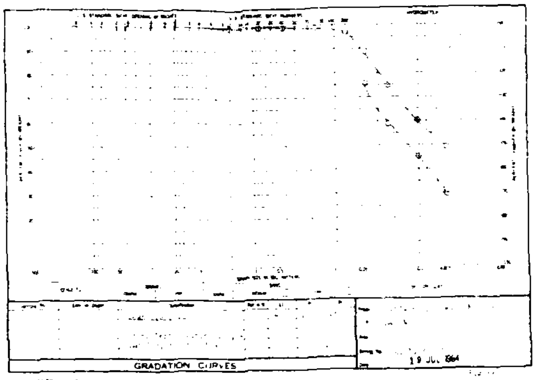
TABLE 1* [illegible]

	Na	[illegible]	[illegible]	Mg	[illegible]	SAR
May	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
November	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

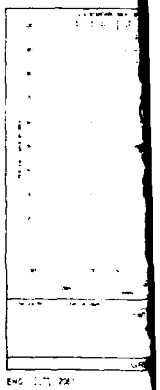
*Concentration corrected [illegible]

[illegible]
Chief, MRD Laboratory

C



ENG [illegible] 2087



B

PINHOLE TEST RESULTS

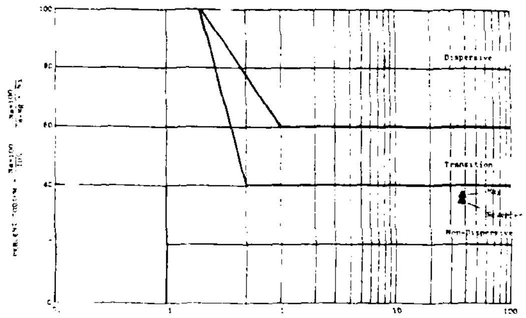
Project: Hillsdale Lake KC 84-84 MRD Lab. No.: 84 [illegible]

Sample	Depth	Head, Inches	Test Time For Given Head, Minutes	Flow Through Specimen, ml/sec	Color of Flow at End of Test	Hole Size after Test, Needle Dia.	Classification
November	-	2	10	[illegible]	Cloudy	[illegible]	[illegible]
May	-	2	10	[illegible]	Cloudy	[illegible]	[illegible]
May	-	2	10	[illegible]	[illegible]	[illegible]	[illegible]
May with 2% lime	-	40	5	0.5	Sparkling Clear	No change	ND[illegible]

A

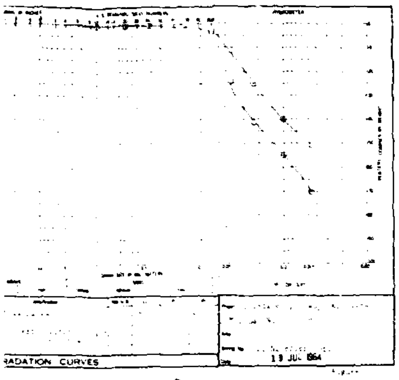
Table [illegible]

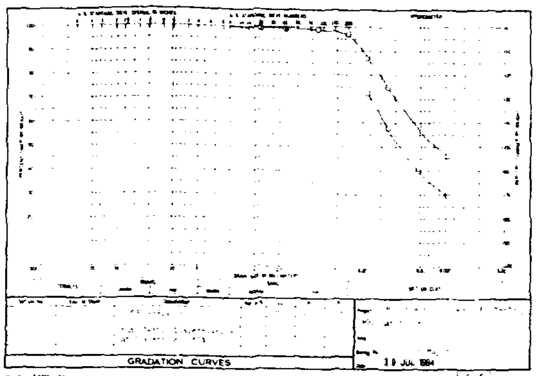
DISPERSIVE CLAY CLASSIFICATION
BY
DISSOLVED SALTS



Figure

5 4 3 2

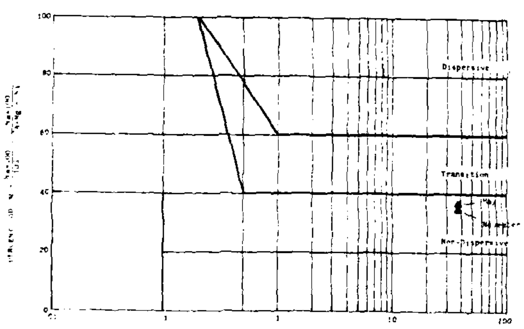




DISPERSIVE CLAY CLASSIFICATION

BY

DISSOLVED SALTS



Revisions			
Symbol	Descriptions	Date	Approved

U. S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
KANSAS CITY, MISSOURI

Designed by
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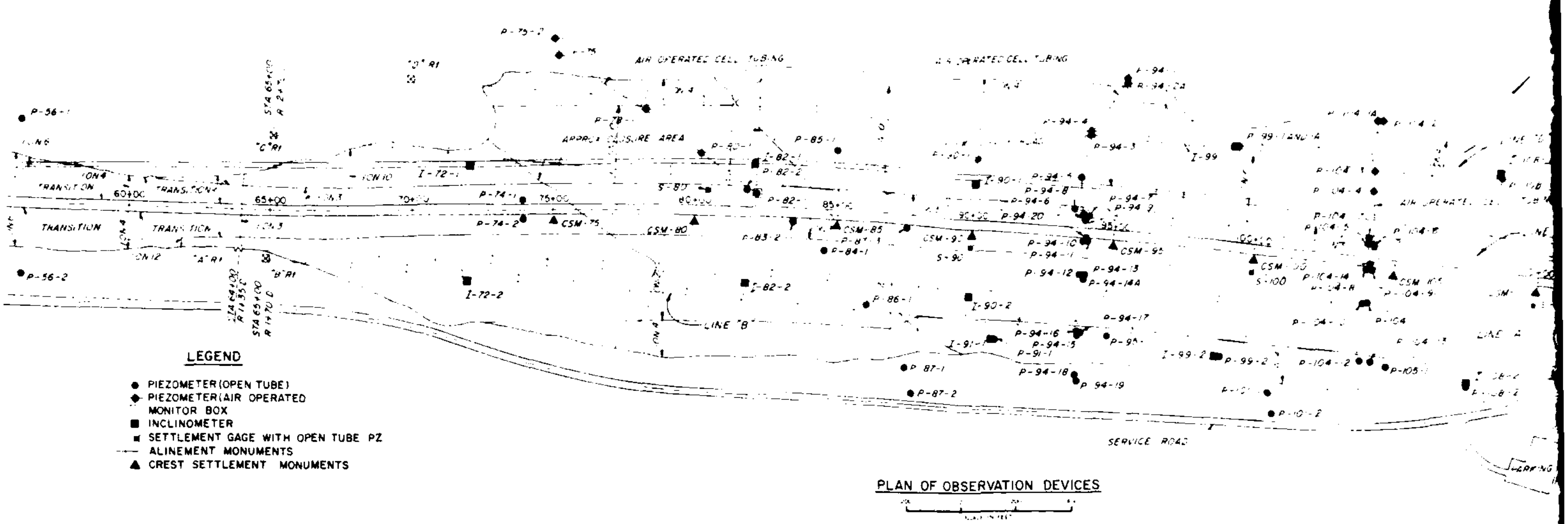
US Army Corps of Engineers

BIG BULL CREEK, KANSAS
HILLSDALE LAKE
EMBANKMENT CRITERIA REPORT

DISPERSION TEST RESULTS

Scale
Date SEPTEMBER 1984
Sheet number 2 of 2
Dwg No.
File No. 0-15-1147

PLATE NO. 151B



PLAN OF OBSERVATION DEVICES

OPEN TUBE PIEZOMETERS

	DEVICE NUMBER	STATION	RANGE	TIP ELEVATION	TOP OF RISER	MATERIAL
	P-56-1	56+00	3+00U	908.0	926.97	RAYTOWN LS
	P-56-2	56+00	2+50D	909.5	929.77	RAYTOWN LS
	P-74-1	74+00	0+18U	856.6	953.28	DRUM LS
	P-74-2	74+00	0-18D	855.5	953.45	DRUM LS
	P-82-1	82+25	[illegible]+60U	847.4	938.53	QUIVIRA SH
	P-82-2	81+91	0+80U	84[illegible].7	934.14	QUIVIRA SH
	P-83-2	83+35	0+25D	858.5	951.80	IMPERVIOUS
	P-84-1	84+65	1+20D	845.1	925.47	DRUM LS
	P-85-1	85+00	2+35U	841.2	917.30	QUIVIRA SH
	P-86-1	86+40	3+20U	838.2	908.93	QUIVIRA SH
	P-87-1	87+75	5+20D	856.3	873.71	OVERBURDEN
	P-87-2	87+65	6+10D	837.8	879.66	QUIVIRA SH
	P-87-3	87+50	0+25D	875.0	951.70	IMPERVIOUS
	P-90-1	90+00	2+35U	842.6	917.55	QUIVIRA SH
	P-91-1	91+10	4+00D	839.0	891.77	QUIVIRA SH
	P-94-6	93+95	0+60U	861.6	938.53	OVERBURDEN
	P-94-7	94+05	0+60U	847.7	938.74	DRUM LS
	P-94-8	93+58	0+80U	842.5	932.29	QUIVIRA SH
	P-94-9	93+95	0+50U	833.1	940.15	WESTERVILLE LS
	P-94-10	93+95	0+25D	881.67	949.53	IMPERVIOUS
	P-94-11	94+05	0+25D	862.4	949.80	IMPERVIOUS
	P-94-12	93+95	1+45D	861.1	922.92	OVERBURDEN
	P-94-13	94+05	1+45D	847.1	922.97	DRUM LS
	P-94-14A	94+05	1+57D	832.4	922.02	WESTERVILLE LS
	P-94-15	93+95	3+55D	859.3	902.65	OVERBURDEN
	P-94-16	93+95	3+50D	841.3	903.9[illegible]	QUIVIRA SH
	P-94-17	94+05	3+50D	832.3	903.[illegible]	WESTERVILLE LS
	P-94-18	93+95	5+00D	852.4	877.63	OVERBURDEN
	P-94-19	94+05	5+20D	843.2	877.[illegible]	QUIVIRA SH
	P-94-20	94+05	0+17D	847.[illegible]	952.65	PERVIOUS
	P-95-1	95+00	3+30D	874.[illegible]	908.0[illegible]	PERVIOUS
*	P-99-1	99+10	3+52U	845.4	897.85	QUIVIRA SH
	P-99-2	99+10	3+88D	842.0	894.55	QUIVIRA SH
	P-101-1	100+95	5+00D	854.6	877.5[illegible]	OVERBURDEN
	P-101-2	101+05	5+75D	837.2	879.[illegible]	QUIVIRA SH
	P-104-5	103+95	0+60U	853.0	938.[illegible]	OVERBURDEN
	P-104-6	104+05	0+55U	846.9	938.90	DRUM LS
	P-104-7	103+95	0+80U	841.2	931.[illegible]	QUIVIRA SH
	P-104-8	103+95	0+25D	879.8	950.80	IMPERVIOUS
	P-104-9	104+05	0+25D	856.8	95[illegible].59	IMPERVIOUS
	P-104-10	103+95	1+45D	856.6	922.87	OVERBURDEN
	P-104-11	104+05	1+45D	845.5	923.20	DRUM LS
	P-104-12	103+95	3+50D	853.8	903.[illegible]	OVERBURDEN
	P-104-13	104+27	3+50D	836.2	904.6[illegible]	QUIVIRA SH
	P-104-14	104+06	0+18D	843.4	952.4[illegible]	IMPERVIOUS
	P-105-1	105+05	3+30D	868.26	902.76	PERVIOUS
	P-108-2	108+10	3+97D	836.4	892.83	QUIVIRA SH
	P-113-2	113+43	0+25U	890.8	94[illegible].72	IMPERVIOUS
	P-113-3	113+09	2+00D	890.57	9[illegible].45	IMPERVIOUS
	P-120-1	120+00	1+75U	878.0	923.[illegible]	RAYTOWN LS
	P-120-2	120+00	1+50D	877.6	928.58	RAYTOWN LS
	A-53	53+[illegible]	2+20[illegible]	885.0	924.34	[illegible]TE SH
	OW-53-2	53+00	2+20D	893.41	936.[illegible]	[illegible]TE SH

* SUBMERGED NO LONGER READ

AIR OPERATED PIEZOMETERS

	DEVICE NUMBER	STATION	RANGE	TIP ELEVATION	MATERIAL	TYPE
	P-75-1	75+[illegible]	[illegible]+50U	867.[illegible]	OVERBURDEN	PET.[illegible]
	P-75-2	75+[illegible]	[illegible]+10U	[illegible]	QUIVIRA SH	S.W.
	P-78-1	78+[illegible]	3+60U	84[illegible]	QUIVIRA SH	S.W.
	P-80-1	80+20	[illegible]+10U	8[illegible]	OVERBURDEN	PET.UR
	P-94-1	95+[illegible]	5+55U	85[illegible]	OVERBURDEN	S.W.
	P-94-2A	93+14	[illegible]+50U	84[illegible]	QUIVIRA SH	S.W.
	P-94-3	93+95	3+50U	84[illegible]	QUIVIRA SH	S.W.
	P-94-4	93+95	3+50U	8[illegible]	WESTERVILLE LS	S.W.
	P-94-5	93+70	[illegible]+00U	86[illegible].4	OVERBURDEN	S.W.
*	P-99-1A	99+10	3+52U	84[illegible].4	QUIVIRA SH	S.W.
	P-104-1A	103+95	[illegible]+03U	86[illegible]	OVERBURDEN	PET.UR
	P-104-2	104+0[illegible]	[illegible]+00U	837[illegible]	QUIVIRA SH	PET.UR
	P-104-3	103+88	3+70U	84[illegible]	QUIVIRA SH	S.W.
	P-104-4	104+05	2+50U	8[illegible]	OVERBURDEN	PET.UR
*	P-108-1	108+20	3+52U	83[illegible].4	QUIVIRA SH	S.W.
	P-113-1	113+72	2+00U	890.[illegible]	IMPERVIOUS	S.W.

* SUBMERGED - NO LONGER READ

INCLINOMETER SCHEDULE

	DEVICE NUMBER	STATION	RANGE	ORIGINAL DEPTH
	[illegible]	72+[illegible]	[illegible]	[illegible]
	[illegible]	7[illegible]	[illegible]	[illegible]
	8[illegible]	82+[illegible]	[illegible]+4[illegible]	[illegible]
	8[illegible]	82+07	[illegible]	[illegible]
	8[illegible]	[illegible]	[illegible]+45	[illegible]
	90-2	90+[illegible]	[illegible]+5[illegible]	[illegible]
*	9[illegible]	9[illegible]+02	4+30[illegible]	[illegible]
	99-1	99+[illegible]	3+[illegible]	[illegible]
	99-2	99+0[illegible]	3+56[illegible]	[illegible]
*	108-1	108+[illegible]	[illegible]	[illegible]
	108-2	108+03	3+97[illegible]	[illegible]
	113-1	113+64	[illegible]	44
	114-1	114+2[illegible]	1+4[illegible]	[illegible]

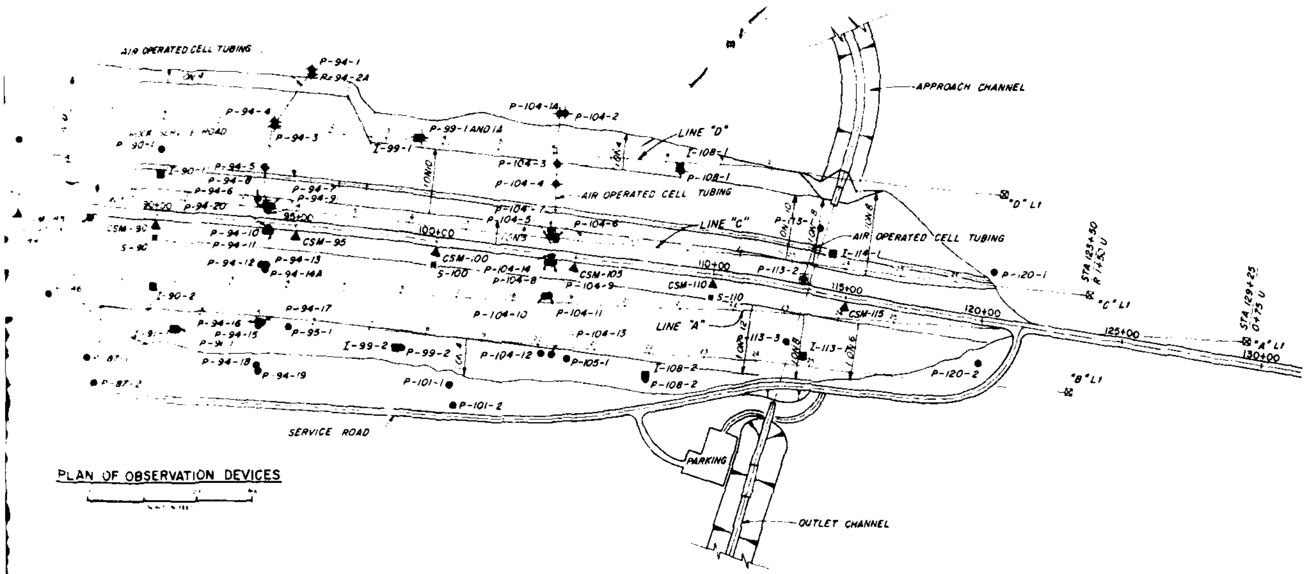
* SUBMERGED - NO LONGER READ

FOUNDATION SETTLEMENT GAGES W/OPEN TUBE PZS

DEVICE NUMBER	STATION	RANGE	TIP ELEVATION	RISER ELEVATION	MATERIAL
S-85	85+5[illegible]	[illegible]+90U	87[illegible]	[illegible]	OVERBURDEN
S-90	90+[illegible]	[illegible]+80U	87[illegible]	[illegible]	OVERBURDEN
S-100	100+[illegible]	0+80U	87[illegible]	[illegible]	OVERBURDEN
S-110	110+0[illegible]	0+80D	874.94	9[illegible]	OVERBURDEN

CREST SETTLEMENT MONUMENTS

DEVICE NUMBER	STATION	RANGE	INITIAL SURVEY ELEVATION
CSM-75	75+00	0+15D	952.04
CSM-80	80+00	0+15D	95[illegible]
CSM-85	85+00	0+15D	95[illegible].68
CSM-90	90+00	0+15D	952.[illegible]
CSM-95	95+00	0+15D	952.0[illegible]
CSM-100	100+00	0+15D	95[illegible]
CSM-105	105+00	0+15D	952.0[illegible]
CSM-110	110+00	0+15D	95[illegible].95
CSM-115	115+00	0+15D	952.[illegible]



PLAN OF OBSERVATION DEVICES

ED PIEZOMETERS

TIP ELEVATION	MATERIAL	TYPE
[illegible]	OVERBURDEN	PETUR
[illegible]	[illegible] SH	S.W.
[illegible]	[illegible] SH	S.W.
[illegible]	OVERBURDEN	PETUR
[illegible]	OVERBURDEN	S.W.
[illegible]	[illegible] SH	S.W.
[illegible]	[illegible] SH	S.W.
[illegible]	WESTERVILLE LS	S.W.
[illegible]	OVERBURDEN	S.W.
[illegible]	[illegible] SH	S.W.
[illegible]	OVERBURDEN	PETUR
[illegible]	[illegible] SH	PETUR
[illegible]	[illegible] SH	S.W.
[illegible]	OVERBURDEN	PETUR
[illegible]	[illegible] SH	S.W.
[illegible]	IMPERVIOUS	S.W.

INCLINOMETER SCHEDULE

DEVICE NUMBER	STATION	RANGE	ORIGINAL DEPTH
I-72-1	72+00	1+70U	80.5
I-72-2	72+00	2+50D	75.9
I-82-1	82+00	1+40U	119.2
I-82-2	82+00	2+50D	112.3
I-90-1	90+00	1+43U	120.7
I-90-2	90+00	2+50D	111.8
* I-91-1	91+00	4+00D	66.[illegible]
I-99-1	99+00	3+52U	85.6
I-99-2	99+00	3+88D	72.7
* I-108-1	108+10	3+52U	80.3
I-108-2	108+00	3+97D	95.4
I-113-1	113+64	2+50D	94.0
I-114-1	114+20	1+40U	108.8

* SUBMERGED - NO LONGER READ

T GAGES W/OPEN TUBE PZS

TIP ELEVATION	RISER ELEVATION	MATERIAL
[illegible]	[illegible]	OVERBURDEN
[illegible]	[illegible]	OVERBURDEN
[illegible]	[illegible]	OVERBURDEN
[illegible]	[illegible]	OVERBURDEN

ONUMENTS

SURVEY ELEVATION

REVISED SEPTEMBER 1984
BIG BULL CREEK KANSAS

HILLSDALE LAKE

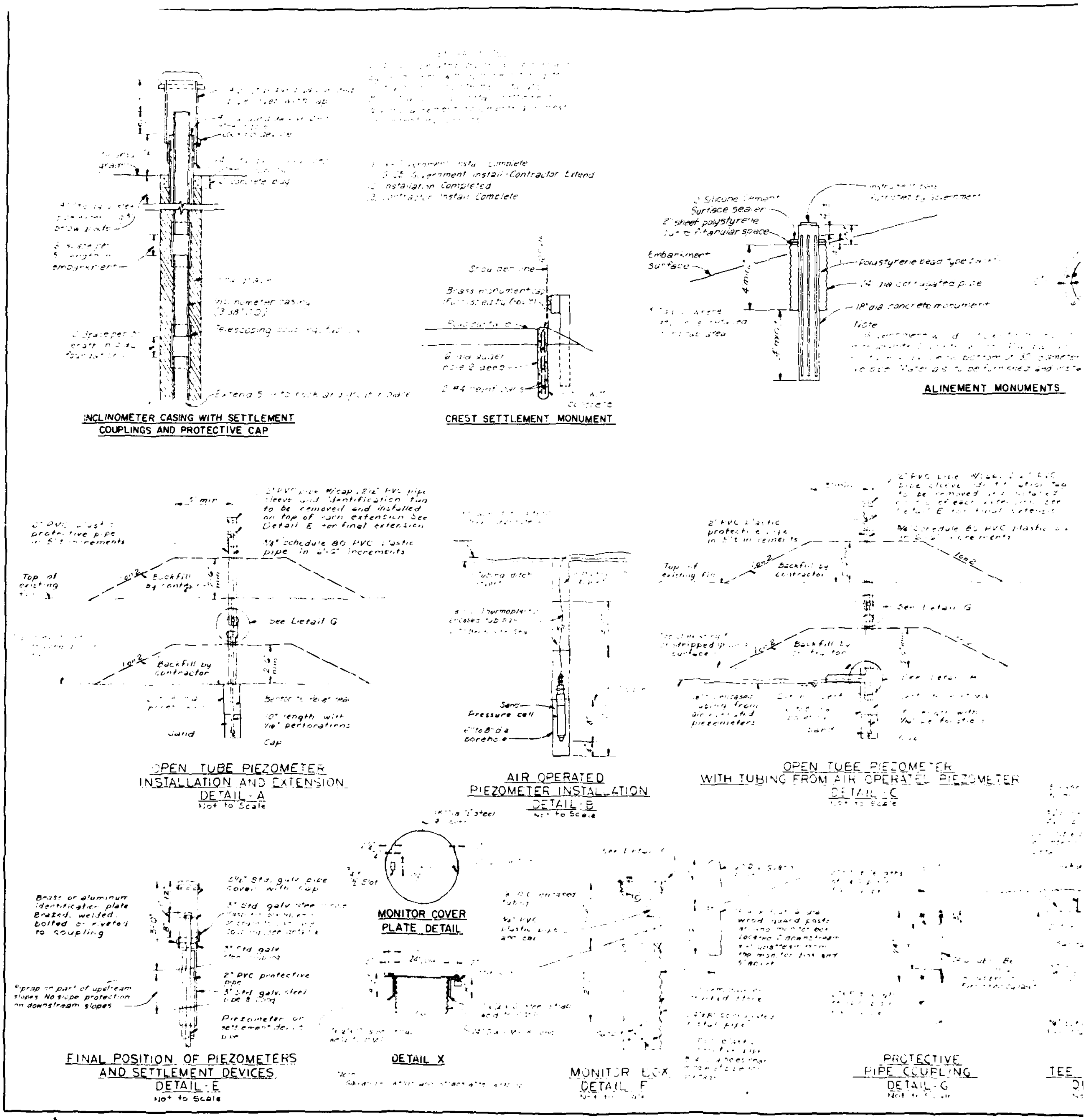
EMBANKMENT CRITERIA REPORT

OBSERVATION DEVICES PLAN AND SCHEDULE

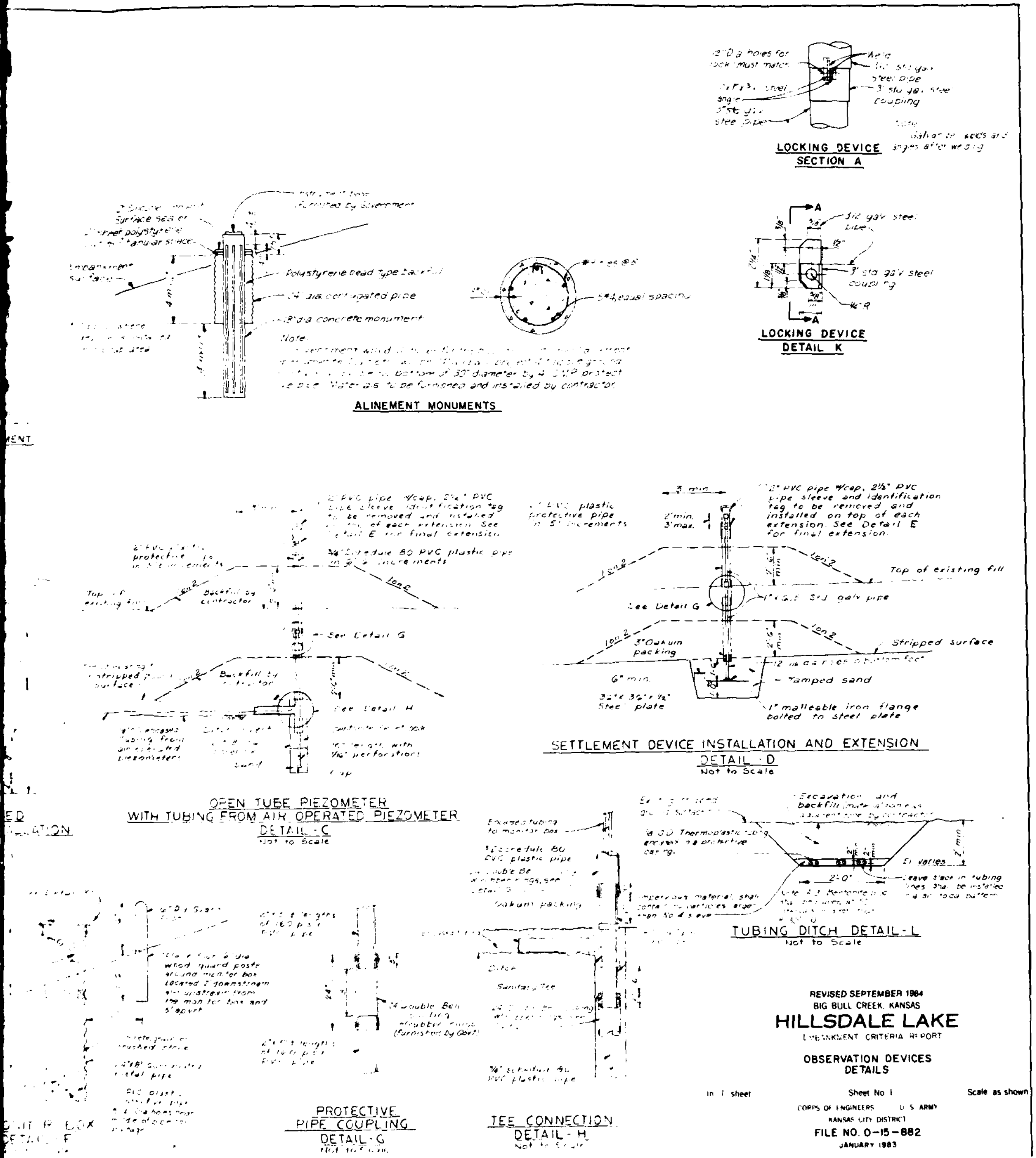
In 1 sheet | Sheet No. 1 | Scale as shown

CORPS OF ENGINEERS U.S. ARMY
KANSAS CITY DISTRICT
FILE NO. O-15-881
JANUARY 1983

PLATE NO. 152



INCLINOMETER CASING WITH SETTLEMENT COUPLINGS AND PROTECTIVE CAP
CREST SETTLEMENT MONUMENT
Brass monument cap (Furnished by Gov't)
2 #4 reinf. bars
ALINEMENT MONUMENTS
Embankment surface
2" sheet polystyrene
Polystyrene bead type filler
18" dia concrete monument
Note
OPEN TUBE PIEZOMETER INSTALLATION AND EXTENSION DETAIL - A
Not to Scale
2" PVC plastic protective pipe in 5'± increments
3/4" schedule 80 PVC plastic pipe in 6'-6" increments
Top of existing fill
Backfill by contractor
See Detail G
10" length with 1/16" perforations
Sand
Cap
AIR OPERATED PIEZOMETER INSTALLATION DETAIL - B
Not to Scale
Tubing ditch
Thermoplastic encased tubing
Sand
Pressure cell
6" to 8" dia borehole
OPEN TUBE PIEZOMETER WITH TUBING FROM AIR OPERATED PIEZOMETER DETAIL - C
Not to Scale
See Detail G
Backfill by contractor
MONITOR COVER PLATE DETAIL
FINAL POSITION OF PIEZOMETERS AND SETTLEMENT DEVICES DETAIL - E
Not to Scale
Brass or aluminum identification plate Brazed, welded, bolted or riveted to coupling
4½" Std. galv. pipe cover with cap
3" Std galv. steel
2" PVC protective pipe
Riprap on part of upstream slopes. No slope protection on downstream slopes
Piezometer or settlement device
DETAIL X
MONITOR BOX DETAIL F
PROTECTIVE PIPE COUPLING DETAIL - G



REVISED SEPTEMBER 1984
BIG BULL CREEK, KANSAS

HILLSDALE LAKE

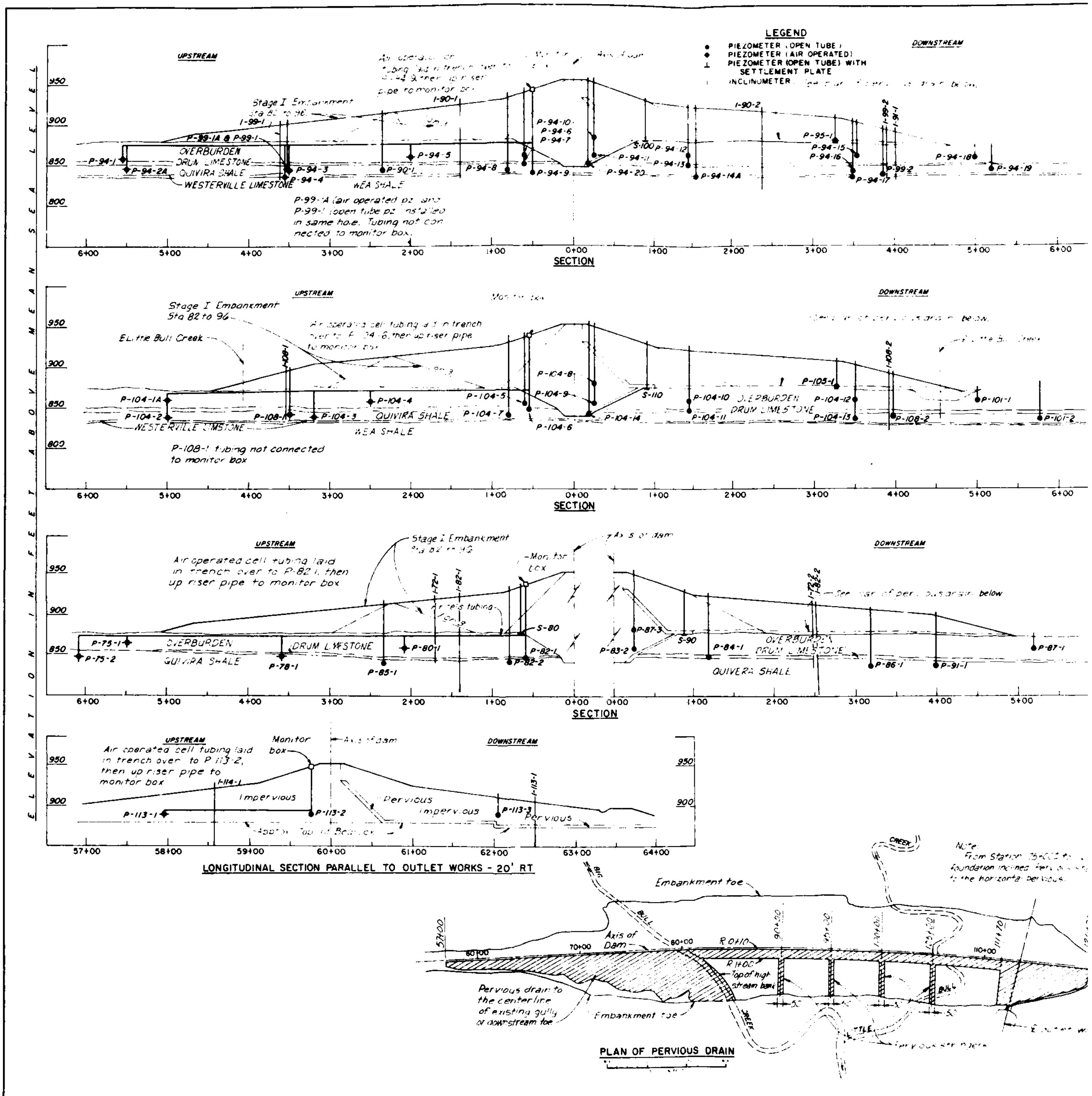
EMBANKMENT CRITERIA REPORT

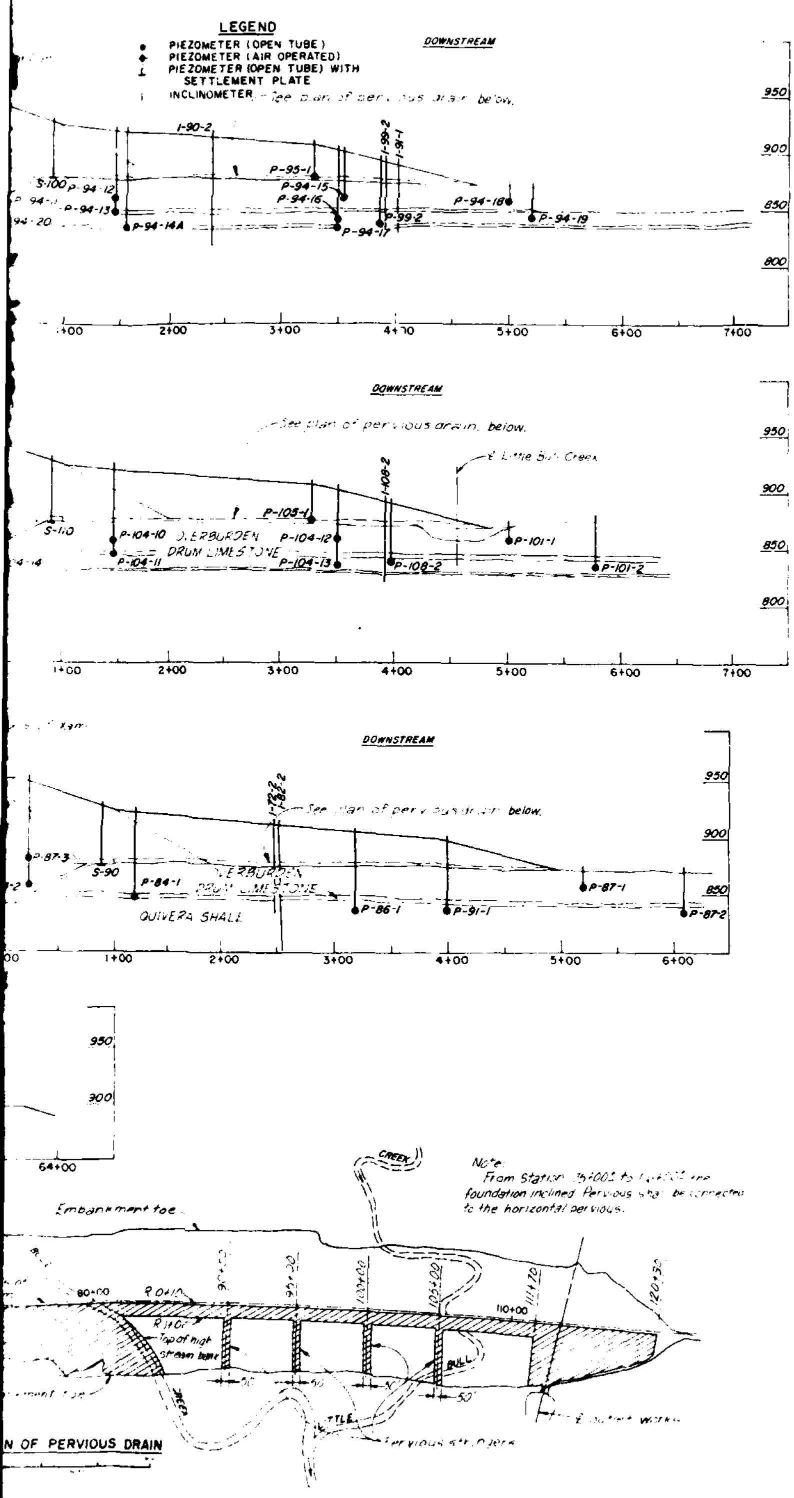
OBSERVATION DEVICES DETAILS

In 1 sheet | Sheet No. 1 | Scale as shown

CORPS OF ENGINEERS U. S. ARMY
KANSAS CITY DISTRICT
FILE NO. 0-15-882
JANUARY 1983

PLATE NO 153


LEGEND
PIEZOMETER (OPEN TUBE)
PIEZOMETER (AIR OPERATED)
PIEZOMETER (OPEN TUBE) WITH SETTLEMENT PLATE
INCLINOMETER
UPSTREAM
DOWNSTREAM
ELEVATION IN FEET ABOVE MEAN SEA LEVEL
950
900
850
800
Stage I Embankment Sta 82 to 96
I-99-1
I-90-1
I-90-2
P-99-1A & P-99-1
OVERBURDEN
DRUM LIMESTONE
QUIVIRA SHALE
WESTERVILLE LIMESTONE
WEA SHALE
P-94-1
P-94-2A
P-94-3
P-94-4
P-94-5
P-90-1
P-94-8
P-94-10
P-94-6
P-94-7
P-94-9
S-100
P-94-12
P-94-11
P-94-13
P-94-20
P-94-14A
P-95-1
P-94-15
P-94-16
P-94-17
I-99-2
I-91-1
P-99-2
P-94-18
P-94-19
P-99-1A (air operated pz. and P-99-1 (open tube pz.) installed in same hole. Tubing not connected to monitor box.
6+00
5+00
4+00
3+00
2+00
1+00
0+00
SECTION
Little Bull Creek
Air operated cell tubing laid in trench over to P-104-6, then up riser pipe to monitor box
I-108-1
I-108-2
P-104-1A
P-104-2
P-108-1
P-104-3
P-104-4
P-104-5
P-104-7
P-104-8
P-104-9
P-104-6
P-104-14
S-110
P-104-10
P-104-11
P-105-1
P-104-12
P-104-13
P-108-2
P-101-1
P-101-2
P-108-1 tubing not connected to monitor box
SECTION
Air operated cell tubing laid in trench over to P-82-1, then up riser pipe to monitor box
Stage I Embankment Sta 82 to 96
Monitor box
Axis of dam
I-72-1
I-82-1
I-72-2
I-82-2
S-80
P-75-1
P-75-2
P-78-1
P-80-1
P-85-1
P-82-1
P-82-2
P-83-2
P-87-3
S-90
P-84-1
P-86-1
P-91-1
P-87-1
DRUM LIMESTONE
QUIVERA SHALE
See plan of pervious drain below
SECTION
Air operated cell tubing laid in trench over to P-113-2, then up riser pipe to monitor box
Monitor box
Axis of dam
I-114-1
I-113-1
P-113-1
P-113-2
P-113-3
Impervious
Pervious
57+00
58+00
59+00
60+00
61+00
62+00
63+00
64+00
LONGITUDINAL SECTION PARALLEL TO OUTLET WORKS - 20' RT
Embankment toe
Axis of Dam
57+00
60+00
70+00
80+00
90+00
110+00
R 0+10
R 1+00 Top of high stream bank
Pervious drain to the centerline of existing gully or downstream toe
Embankment toe
BIG BULL CREEK
Note: From Station 75+00 to ... foundation inclined pervious ... to the horizontal pervious.
PLAN OF PERVIOUS DRAIN



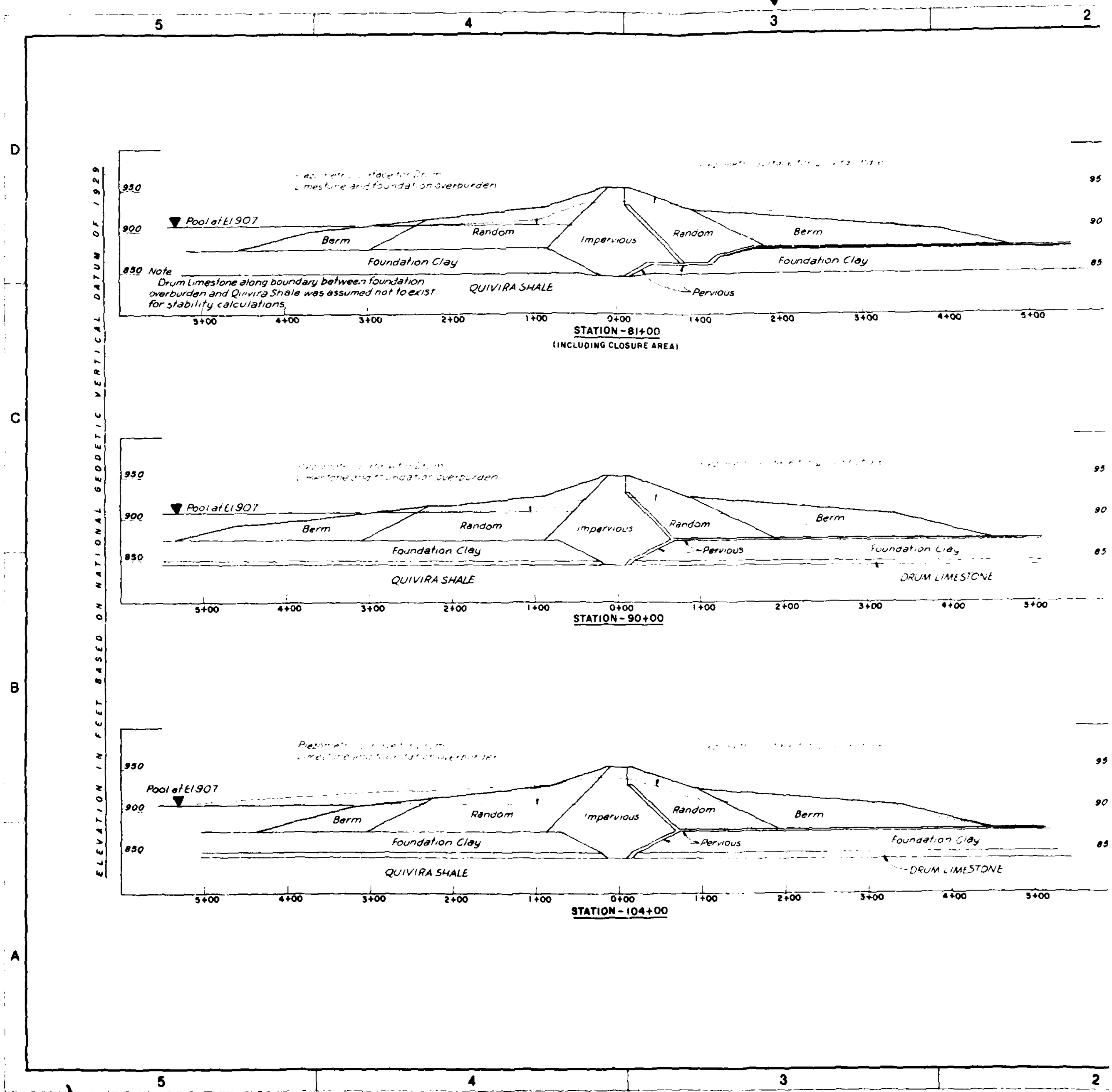
REVISED SEPTEMBER 1984
BIG BULL CREEK, KANSAS
HILLSDALE LAKE
EMBANKMENT CRITERIA REPORT

OBSERVATION DEVICES
SECTIONS

In 1 sheet | Sheet No 1 | Scale as shown

CORPS OF ENGINEERS U. S. ARMY
KANSAS CITY DISTRICT
FILE NO 0-15-883
JANUARY 1983

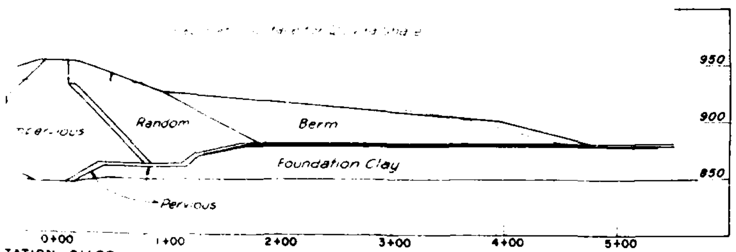
PLATE NO 154



5
4
3
2
D
C
B
A
ELEVATION IN FEET BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929
950
900
850
Pool at El 907
Berm
Random
Impervious
Random
Berm
Foundation Clay
Foundation Clay
Note
Drum Limestone along boundary between foundation overburden and Quivira Shale was assumed not to exist for stability calculations.
QUIVIRA SHALE
Pervious
5+00
4+00
3+00
2+00
1+00
0+00
1+00
2+00
3+00
4+00
5+00
STATION - 81+00
(INCLUDING CLOSURE AREA)
950
900
850
Pool at El 907
Berm
Random
Impervious
Random
Berm
Foundation Clay
Pervious
Foundation Clay
QUIVIRA SHALE
DRUM LIMESTONE
5+00
4+00
3+00
2+00
1+00
0+00
1+00
2+00
3+00
4+00
5+00
STATION - 90+00
950
900
850
Pool at El 907
Berm
Random
Impervious
Random
Berm
Foundation Clay
Pervious
Foundation Clay
QUIVIRA SHALE
DRUM LIMESTONE
5+00
4+00
3+00
2+00
1+00
0+00
1+00
2+00
3+00
4+00
5+00
STATION - 104+00

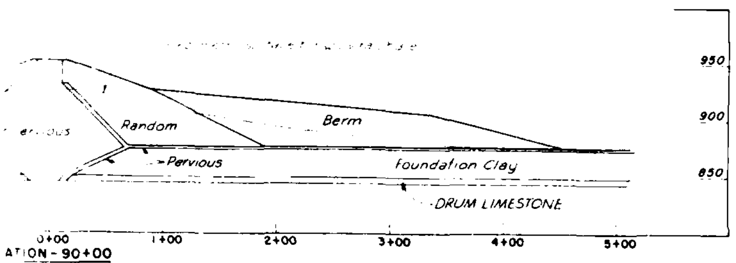
3 | 2 | 1

D



TATION - 81+00
(DING CLOSURE AREA)

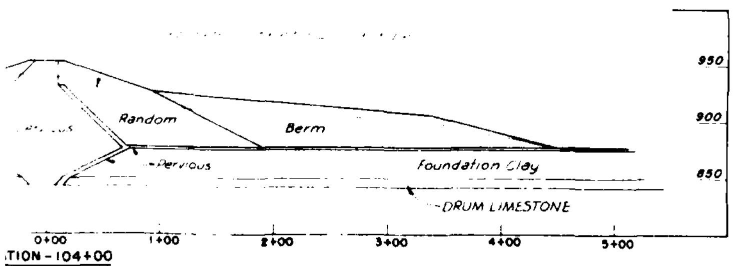
C



ATION - 90+00

Note
All piezometric surfaces are shown as they existed July 1983 with the pool at El 907

B



TION - 104+00

A

Revisions			
Symbol	Descriptions	Date	Approved

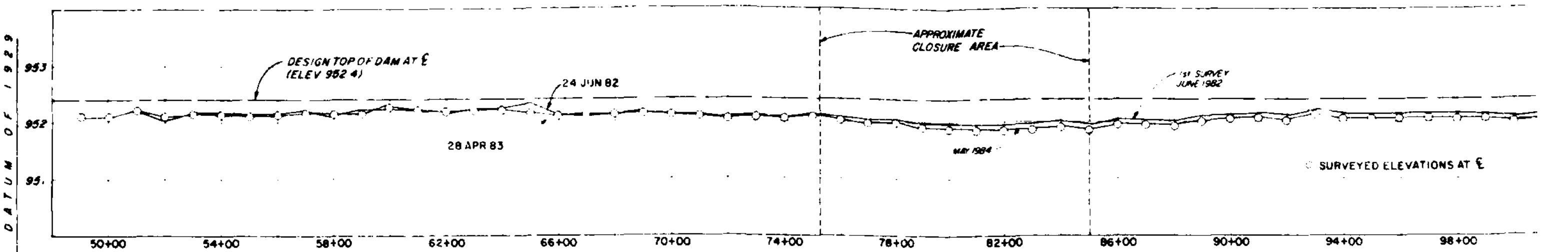
U. S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
KANSAS CITY, MISSOURI

Designed by:	BIG BULL CREEK, KANSAS HILLSDALE LAKE EMBANKMENT CRITERIA REPORT
Drawn by: D.E.J.	PIEZOMETRIC SURFACES
Checked by:	Scale: AS SHOWN — Sheet number
Submitted by:	Date: SEPTEMBER 1984
	Dwg. No. — 1 of 1 — File No. 0-15-1057

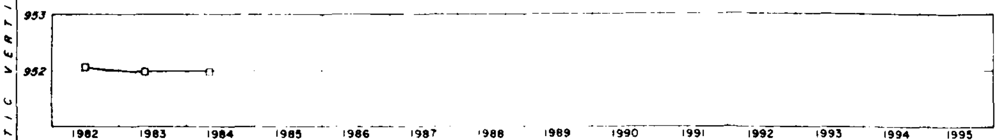
3 | 2 | 1

PLATE NO. 154A

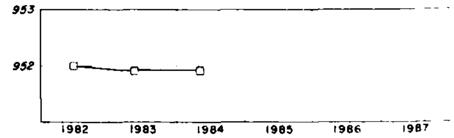
ELEVATION IN FEET BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929



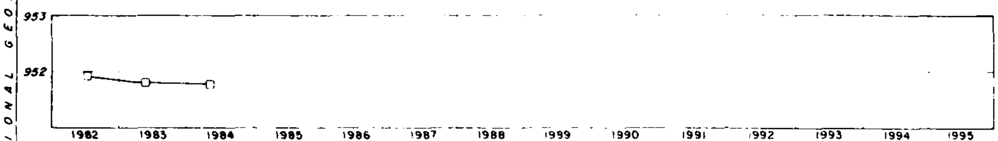
PROFILE ℄ DAM



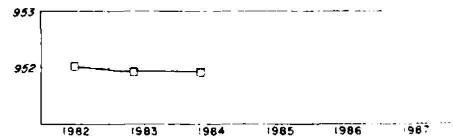
CSM-75 STATION 75+00 RO+15 D.S



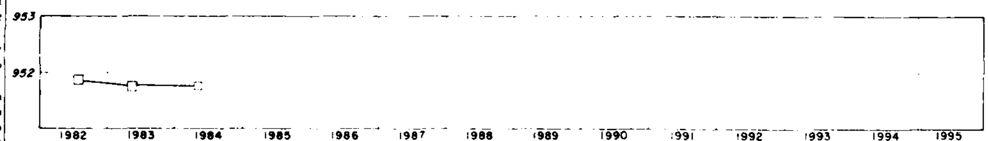
CSM-100



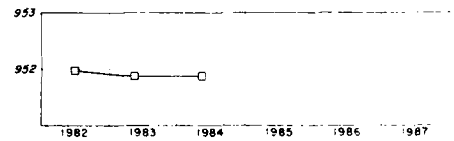
CSM-80 STATION 80+00 RO+15 D.S



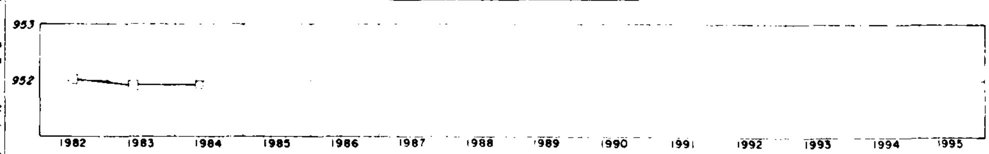
CSM-105



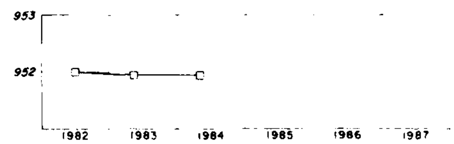
CSM-85 STATION 85+00 RO+15 D.S



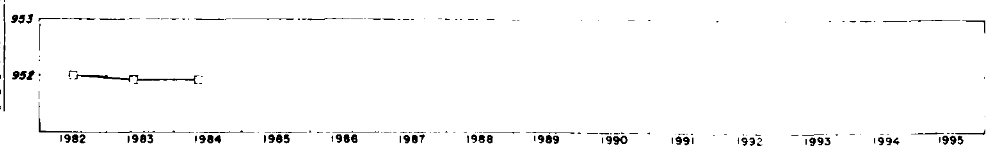
CSM-110



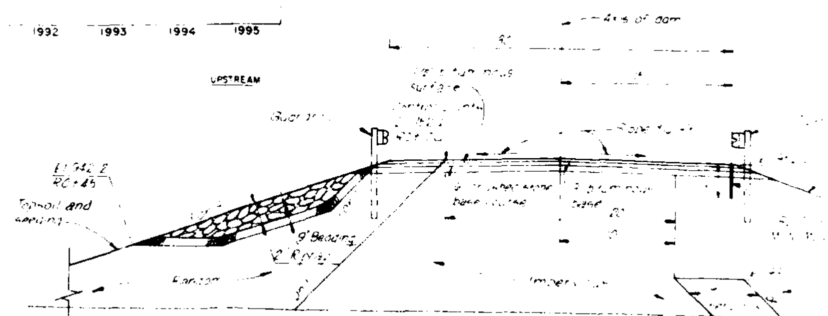
CSM-90 STATION 90+00 RO+15 D.S.



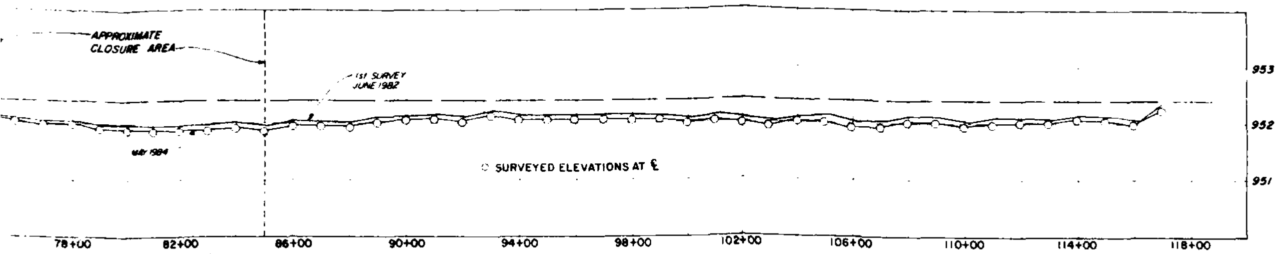
CSM-115



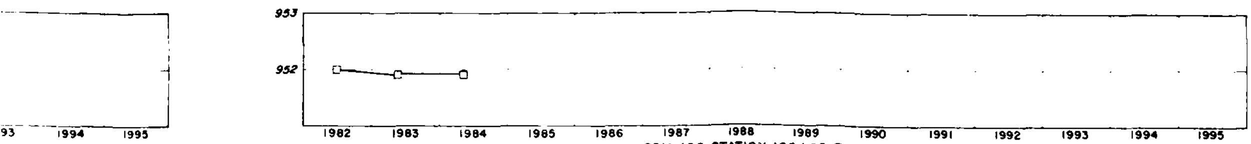
CSM-95 STATION 95+00 RO+15 D.S



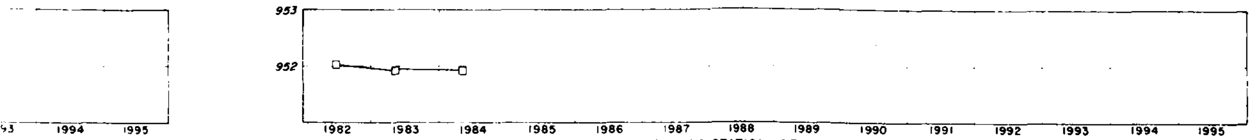
TYPICAL TOP OF DAM DETAIL



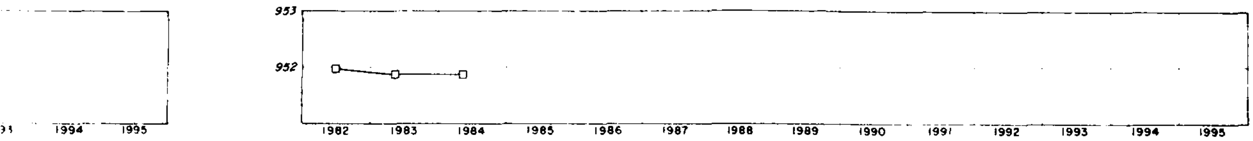
STATION
PROFILE ℄ DAM



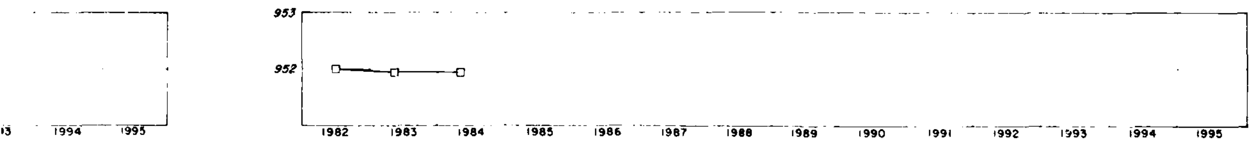
CSM-100 STATION 100+00 R0+15 D.S.



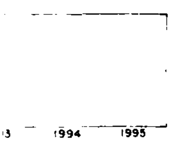
CSM-105 STATION 105+00 R0+15 D.S.

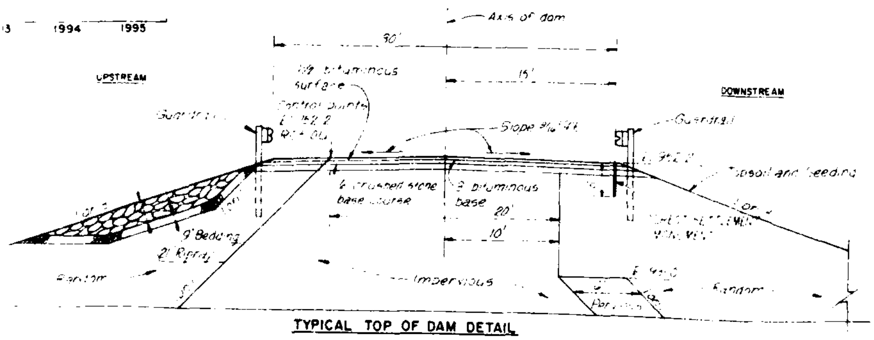


CSM-110 STATION 110+00 R0+15 D.S.



CSM-115 STATION 115+00 R0+15 D.S.





TYPICAL TOP OF DAM DETAIL

REVISED SEPTEMBER 1984
BIG BULL CREEK KANSAS
HILLSDALE LAKE

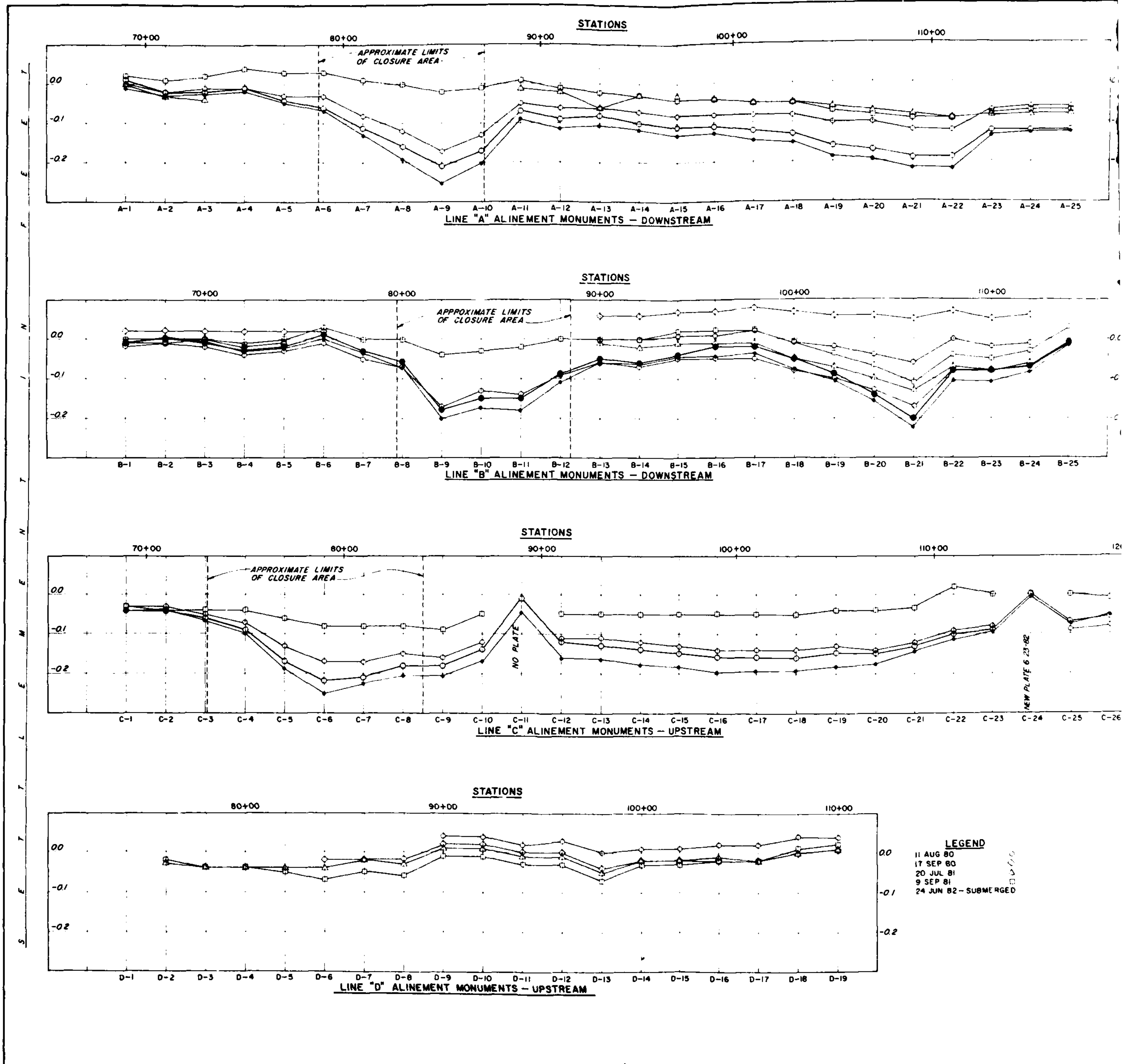
CREST SETTLEMENT MONUMENTS
AND PROFILE ALONG ℄ OF DAM

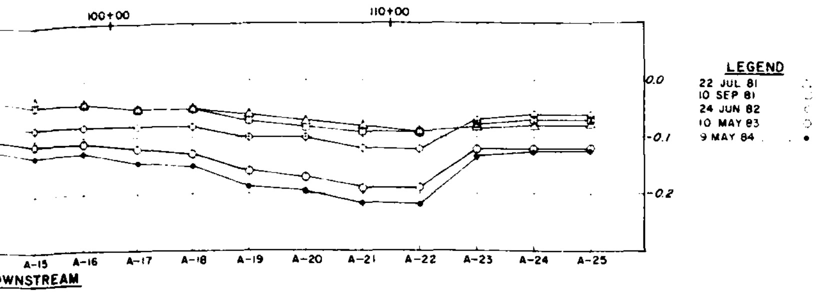
In 1 sheet
Sheet No 1
Scale as shown

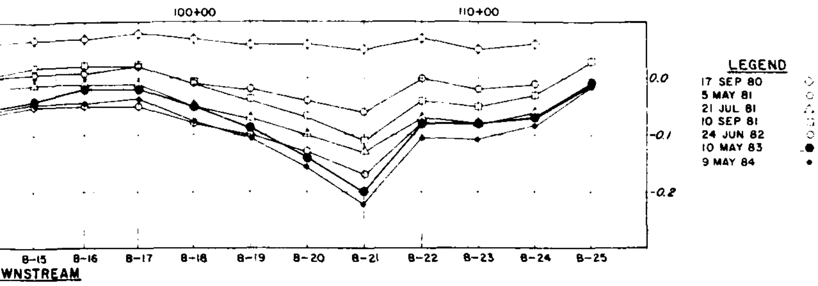
CORPS OF ENGINEERS U.S. ARMY
KANSAS CITY DISTRICT

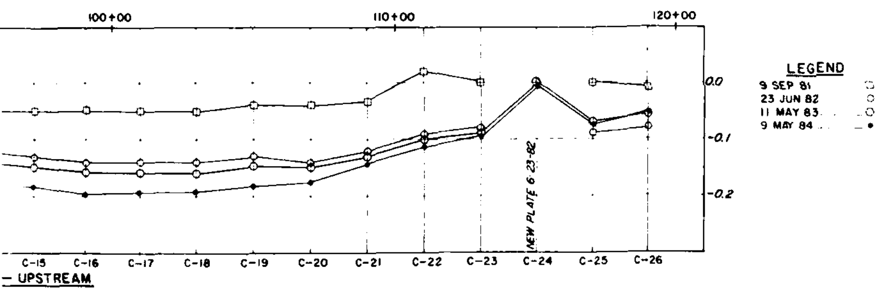
FILE NO 0-15-884
JANUARY 1983

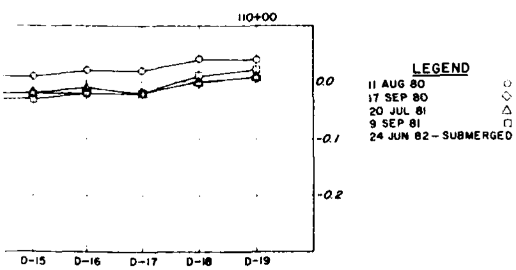
PLATE NO 155


SETTLEMENT IN FEET
STATIONS
70+00
80+00
90+00
100+00
110+00
APPROXIMATE LIMITS OF CLOSURE AREA
0.0
-0.1
-0.2
A-1 A-2 A-3 A-4 A-5 A-6 A-7 A-8 A-9 A-10 A-11 A-12 A-13 A-14 A-15 A-16 A-17 A-18 A-19 A-20 A-21 A-22 A-23 A-24 A-25
LINE "A" ALINEMENT MONUMENTS — DOWNSTREAM
STATIONS
70+00
80+00
90+00
100+00
110+00
APPPROXIMATE LIMITS OF CLOSURE AREA
0.0
-0.1
-0.2
B-1 B-2 B-3 B-4 B-5 B-6 B-7 B-8 B-9 B-10 B-11 B-12 B-13 B-14 B-15 B-16 B-17 B-18 B-19 B-20 B-21 B-22 B-23 B-24 B-25
LINE "B" ALINEMENT MONUMENTS — DOWNSTREAM
STATIONS
70+00
80+00
90+00
100+00
110+00
APPROXIMATE LIMITS OF CLOSURE AREA
0.0
-0.1
-0.2
NO PLATE
NEW PLATE 6-23-82
C-1 C-2 C-3 C-4 C-5 C-6 C-7 C-8 C-9 C-10 C-11 C-12 C-13 C-14 C-15 C-16 C-17 C-18 C-19 C-20 C-21 C-22 C-23 C-24 C-25 C-26
LINE "C" ALINEMENT MONUMENTS — UPSTREAM
STATIONS
80+00
90+00
100+00
110+00
0.0
-0.1
-0.2
D-1 D-2 D-3 D-4 D-5 D-6 D-7 D-8 D-9 D-10 D-11 D-12 D-13 D-14 D-15 D-16 D-17 D-18 D-19
LINE "D" ALINEMENT MONUMENTS — UPSTREAM
LEGEND
11 AUG 80
17 SEP 80
20 JUL 81
9 SEP 81
24 JUN 82 — SUBMERGED









REVISED SEPTEMBER 1984

BIG BULL CREEK, KANSAS

HILLSDALE LAKE

EMBANKMENT CRITERIA REPORT

ALINEMENT MONUMENTS
LINES A, B, C AND D
VERTICAL SUMMARYS

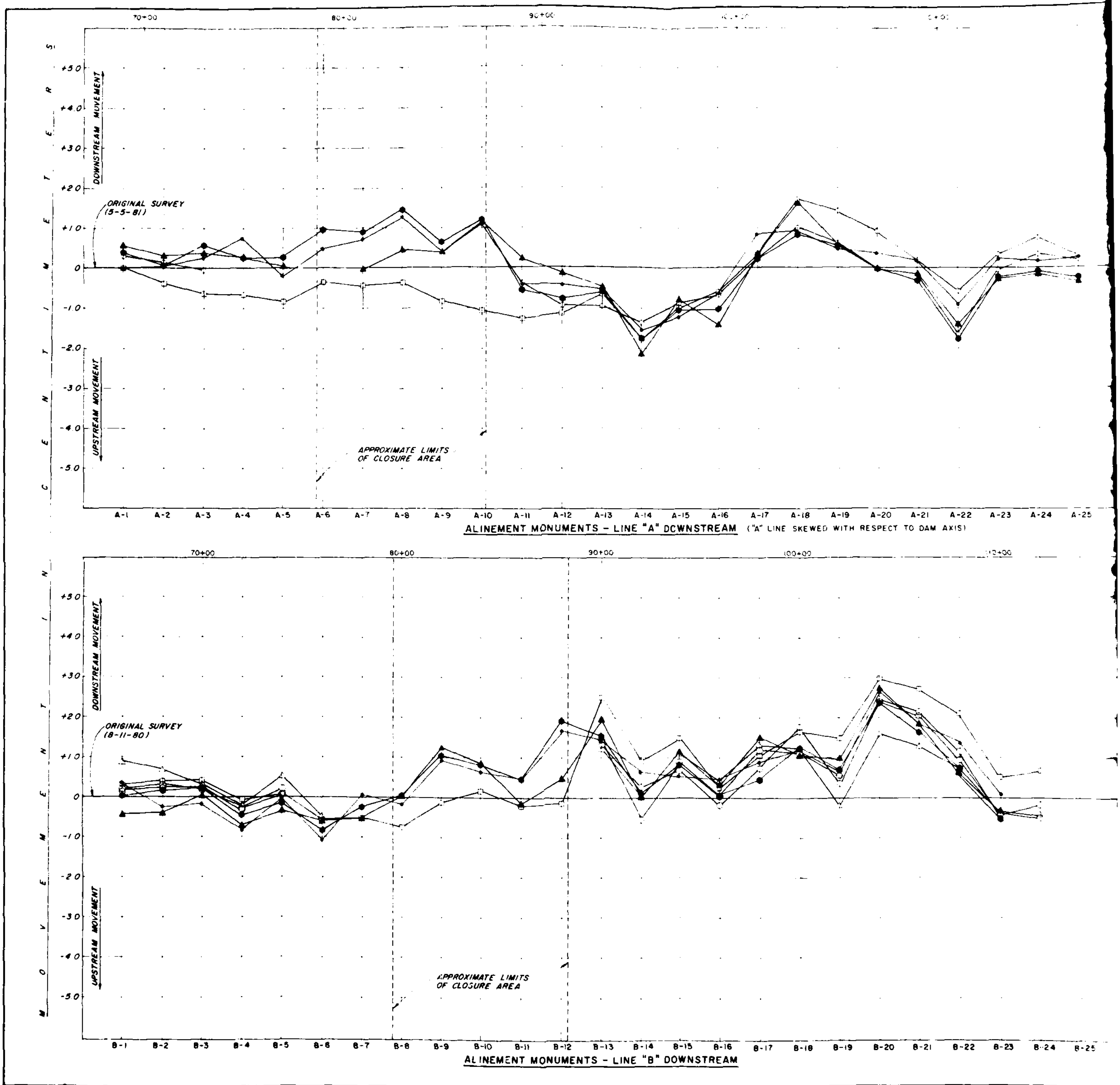
In 1 sheet — Sheet No 1 — Scale as shown

CORPS OF ENGINEERS U. S. ARMY
KANSAS CITY DISTRICT

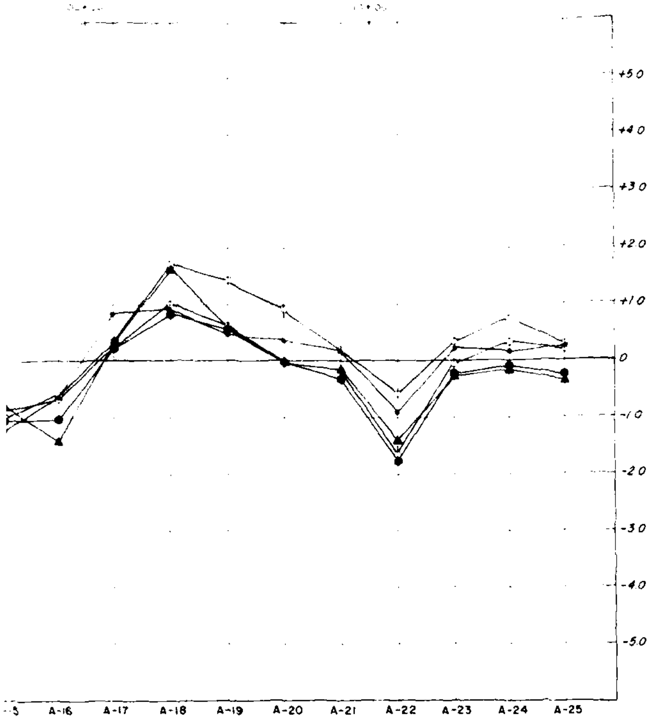
FILE NO 0-15-885

JANUARY 1983

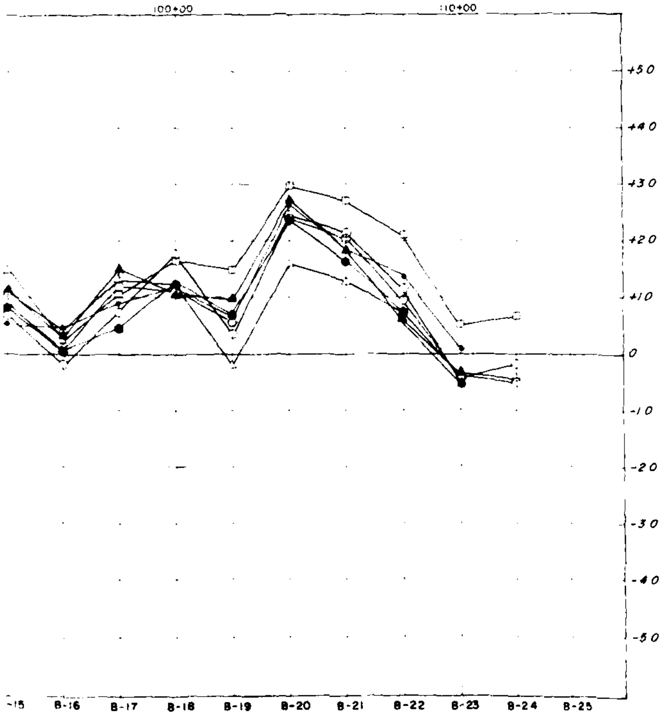
PLATE NO 156



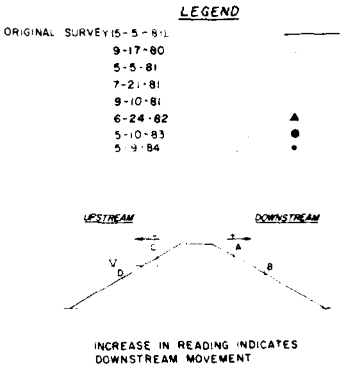
MOVEMENT IN CENTIMETERS
DOWNSTREAM MOVEMENT
UPSTREAM MOVEMENT
ORIGINAL SURVEY (5-5-81)
APPROXIMATE LIMITS OF CLOSURE AREA
70+00
80+00
90+00
+5.0
+4.0
+3.0
+2.0
+1.0
0
-1.0
-2.0
-3.0
-4.0
-5.0
A-1 A-2 A-3 A-4 A-5 A-6 A-7 A-8 A-9 A-10 A-11 A-12 A-13 A-14 A-15 A-16 A-17 A-18 A-19 A-20 A-21 A-22 A-23 A-24 A-25
ALINEMENT MONUMENTS - LINE "A" DOWNSTREAM ("A" LINE SKEWED WITH RESPECT TO DAM AXIS)
ORIGINAL SURVEY (8-11-80)
APPROXIMATE LIMITS OF CLOSURE AREA
70+00
80+00
90+00
100+00
B-1 B-2 B-3 B-4 B-5 B-6 B-7 B-8 B-9 B-10 B-11 B-12 B-13 B-14 B-15 B-16 B-17 B-18 B-19 B-20 B-21 B-22 B-23 B-24 B-25
ALINEMENT MONUMENTS - LINE "B" DOWNSTREAM



WNSTREAM ("A" LINE SKEWED WITH RESPECT TO DAM AXIS)



WNSTREAM



REVISED SEPTEMBER 1984
BIG BULL CREEK, KANSAS

HILLSDALE LAKE

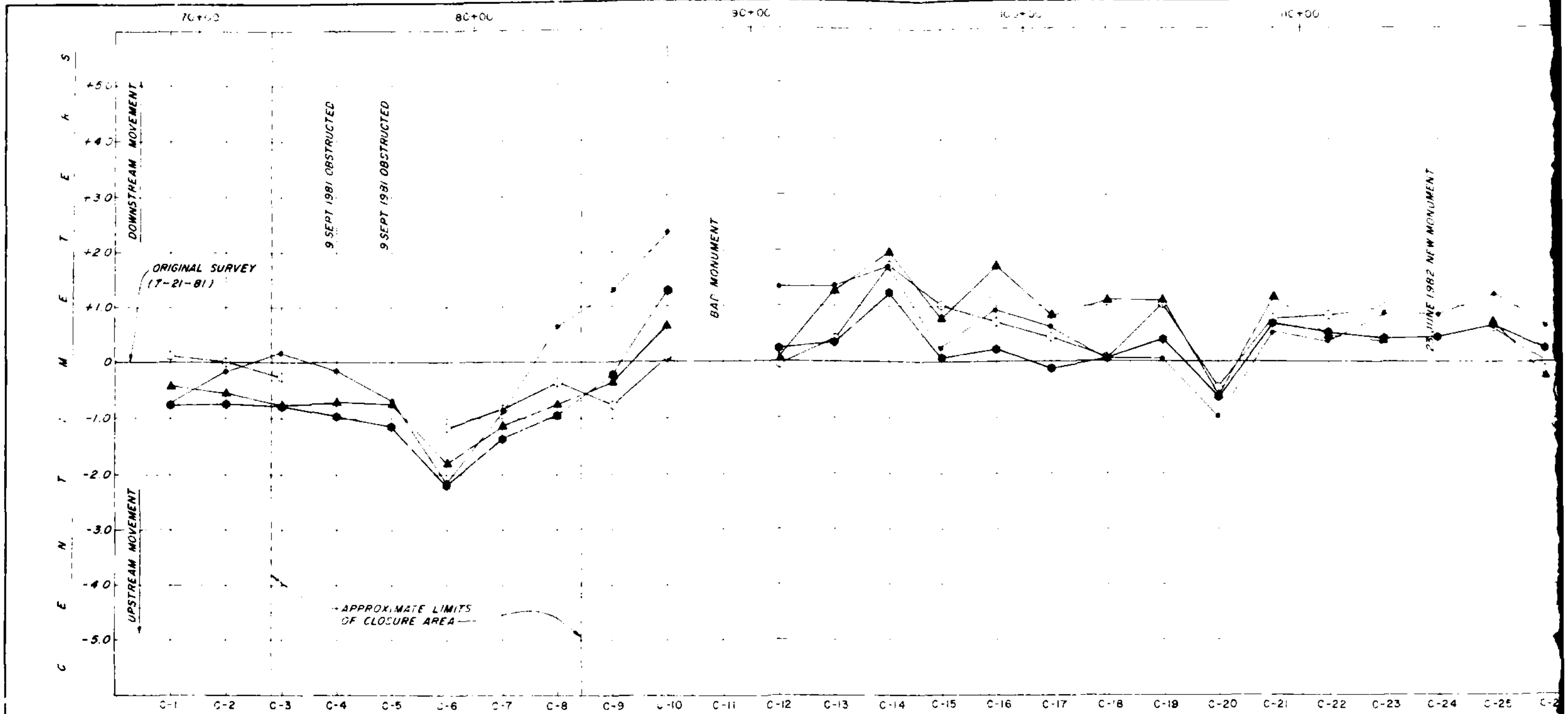
DOWNSTREAM
ALINEMENT MONUMENTS LINES
A AND B HORIZONTAL SUMMARY

Sheet No. | Scale as shown

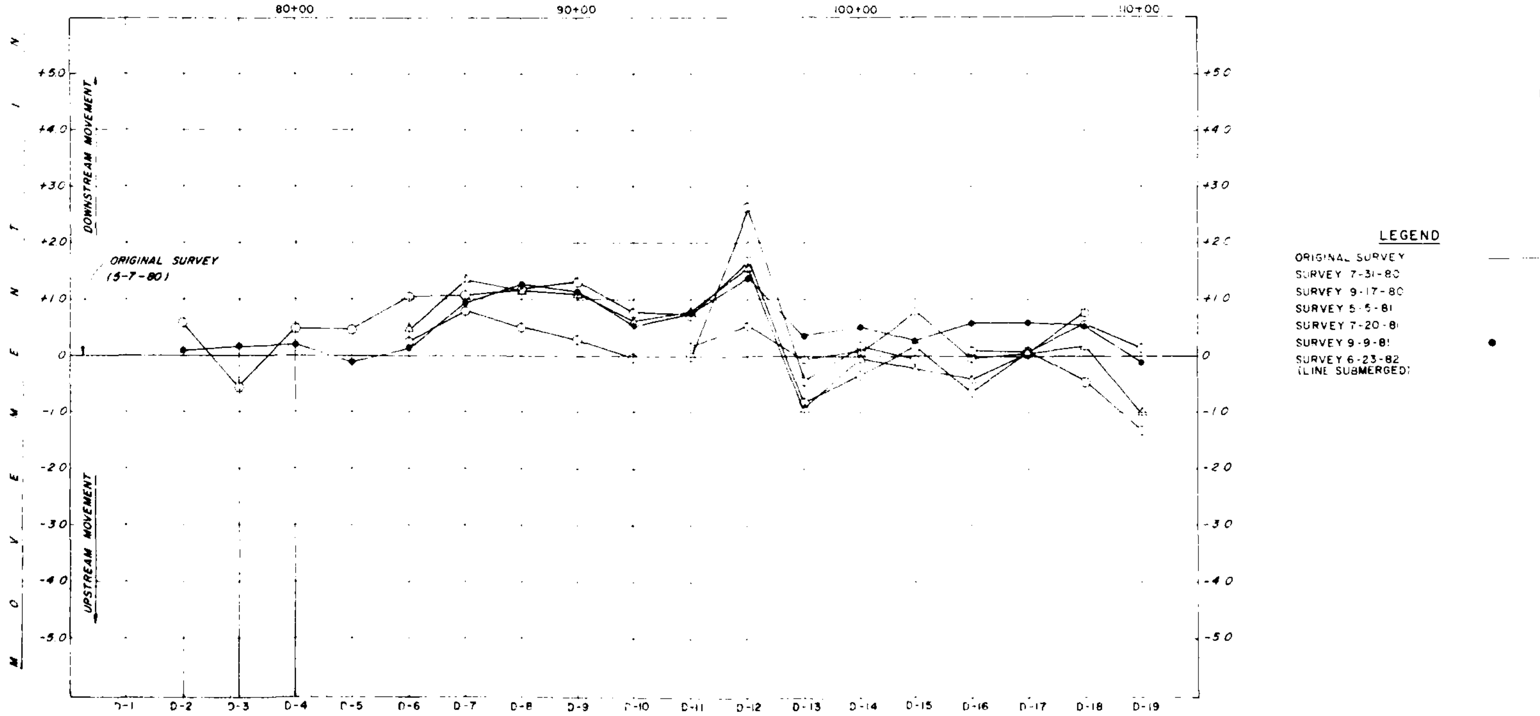
KANSAS CITY DISTRICT

FILE NO. 0-15-886
JANUARY 1983

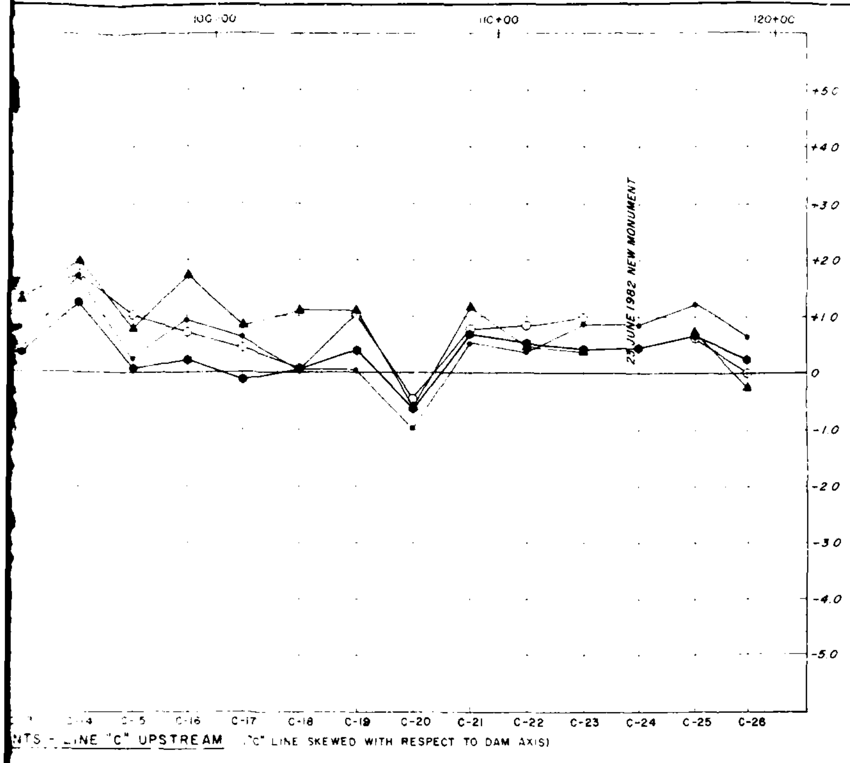
PLATE NO 15



ALINEMENT MONUMENTS - LINE "C" UPSTREAM ("C" LINE SKEWED WITH RESPECT TO DAM AXIS)



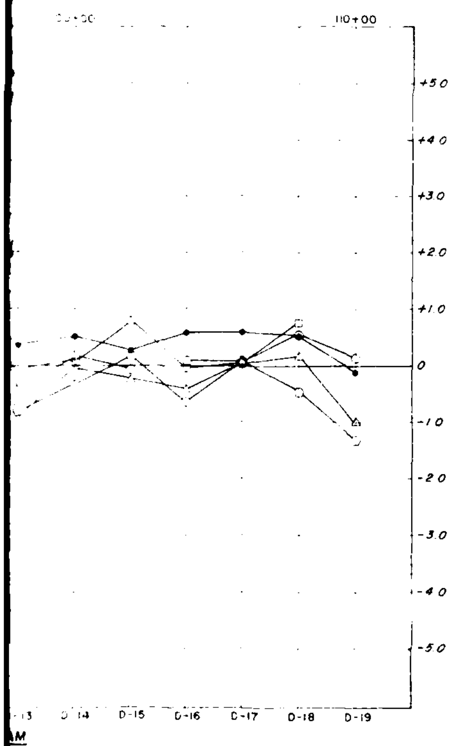
ALINEMENT MONUMENTS - LINE "D" UPSTREAM



NTS - LINE "C" UPSTREAM ("C" LINE SKEWED WITH RESPECT TO DAM AXIS)

LEGEND

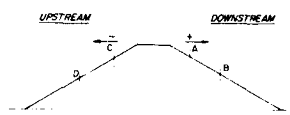
ORIGINAL SURVEY
9-9-81
6-23-82 ▲
5-10-83 ●
5-9-84 •



AM

LEGEND

ORIGINAL SURVEY
SURVEY 7-31-80
SURVEY 9-17-80
SURVEY 5-5-81
SURVEY 7-20-81
SURVEY 9-9-81 ●
SURVEY 6-23-82
(LINE SUBMERGED)



NOTE:
INCREASE IN READING INDICATES DOWNSTREAM MOVEMENT
DECREASE IN READINGS INDICATES UPSTREAM MOVEMENT.

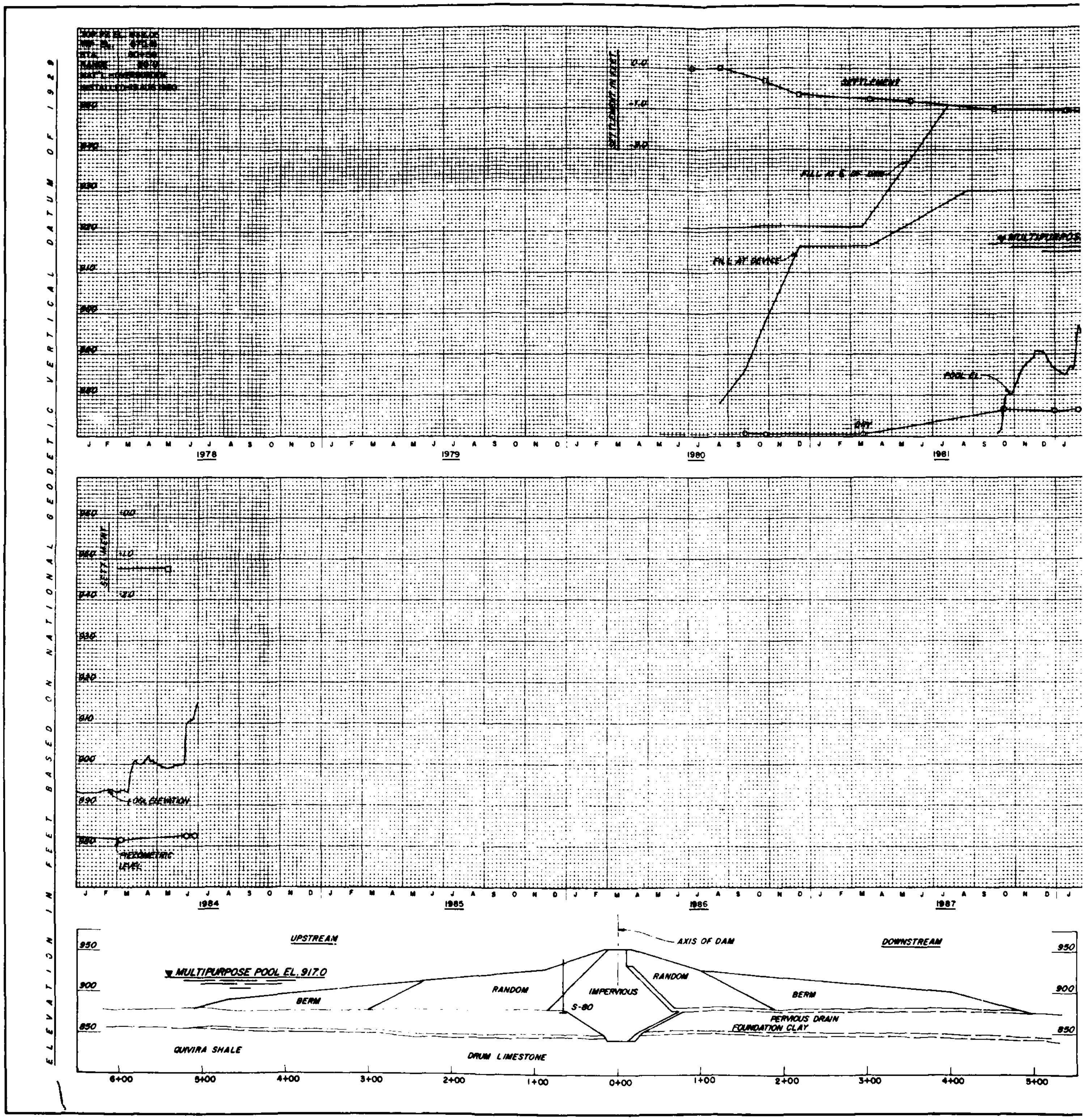
REVISED SEPTEMBER 1984
BIG BULL CREEK KANSAS
HILLSDALE LAKE
UPSTREAM
ALINEMENT MONUMENTS LINES
C AND D HORIZONTAL SUMMARY

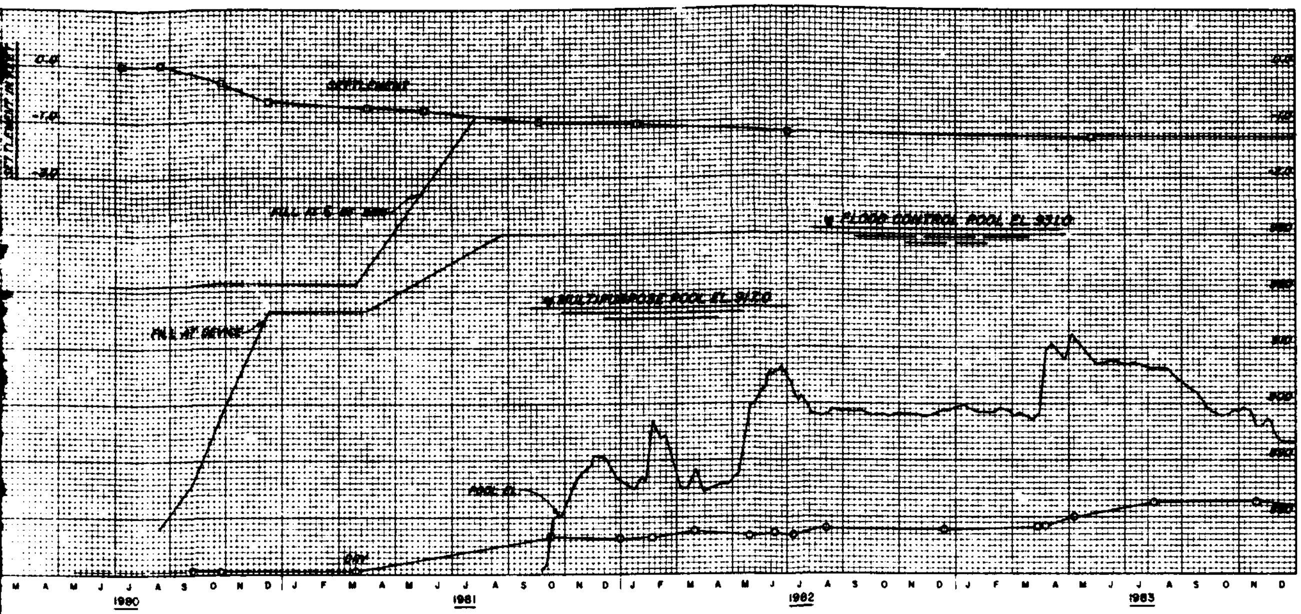
sheet Sheet No 1 Scale as shown

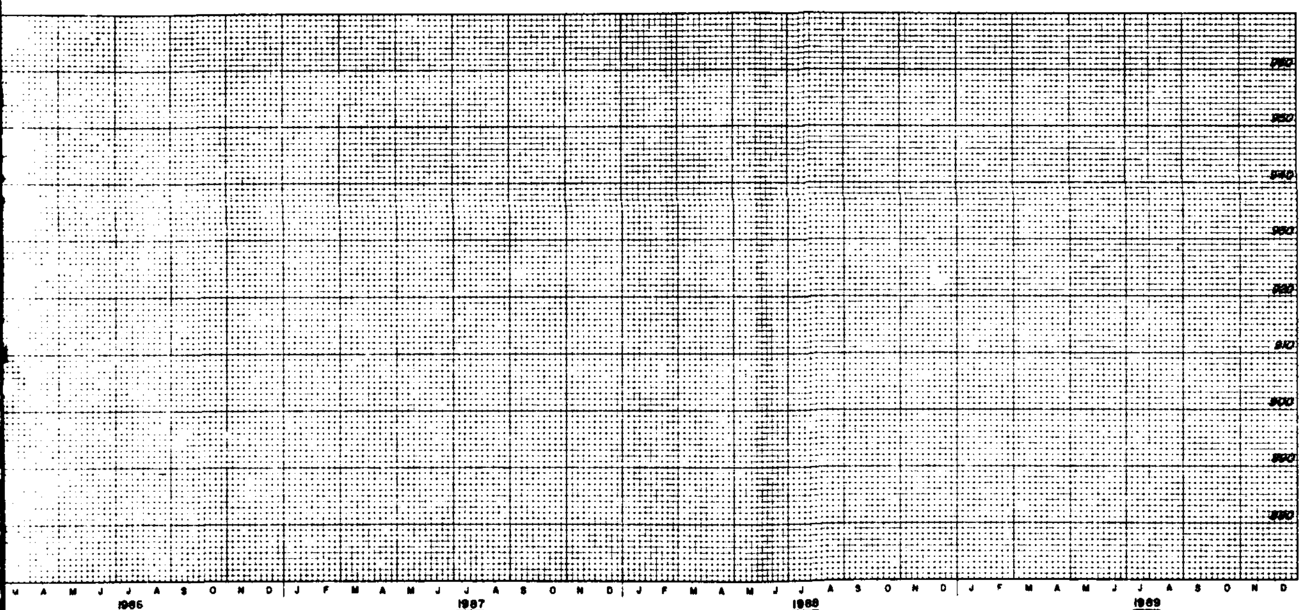
CORPS OF ENGINEERS U. S. ARMY
KANSAS CITY DISTRICT
FILE NO. 0-15-887
JANUARY 1983

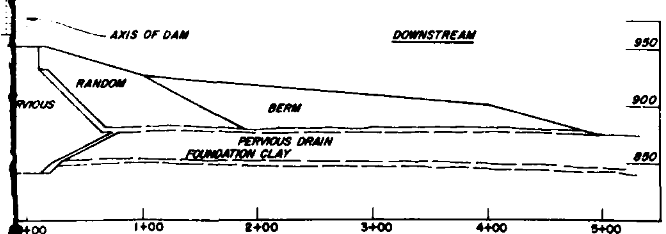
2

PLATE NO 156


ELEVATION IN FEET BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929
SETTLEMENT
FILL AT DEVICE
POOL EL.
1978
1979
1980
1981
PIEZOMETRIC LEVEL
POOL ELEVATION
1984
1985
1986
1987
UPSTREAM
AXIS OF DAM
DOWNSTREAM
MULTIPURPOSE POOL EL. 917.0
RANDOM
IMPERVIOUS
BERM
S-80
PERVIOUS DRAIN
FOUNDATION CLAY
QUIVIRA SHALE
DRUM LIMESTONE
950
900
850
6+00
5+00
4+00
3+00
2+00
1+00
0+00







LEGEND

SETTLEMENT ---------□

PIEZOMETRIC LEVEL ---○

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BIG BULL CREEK, KANSAS

HILLSDALE LAKE

EMBANKMENT CRITERIA REPORT

FOUNDATION SETTLEMENT PLATE AND OPEN TUBE PIEZOMETER S-60

In 1 sheet | Sheet No. 1 | Scale: as shown

CORPS OF ENGINEERS U. S. ARMY

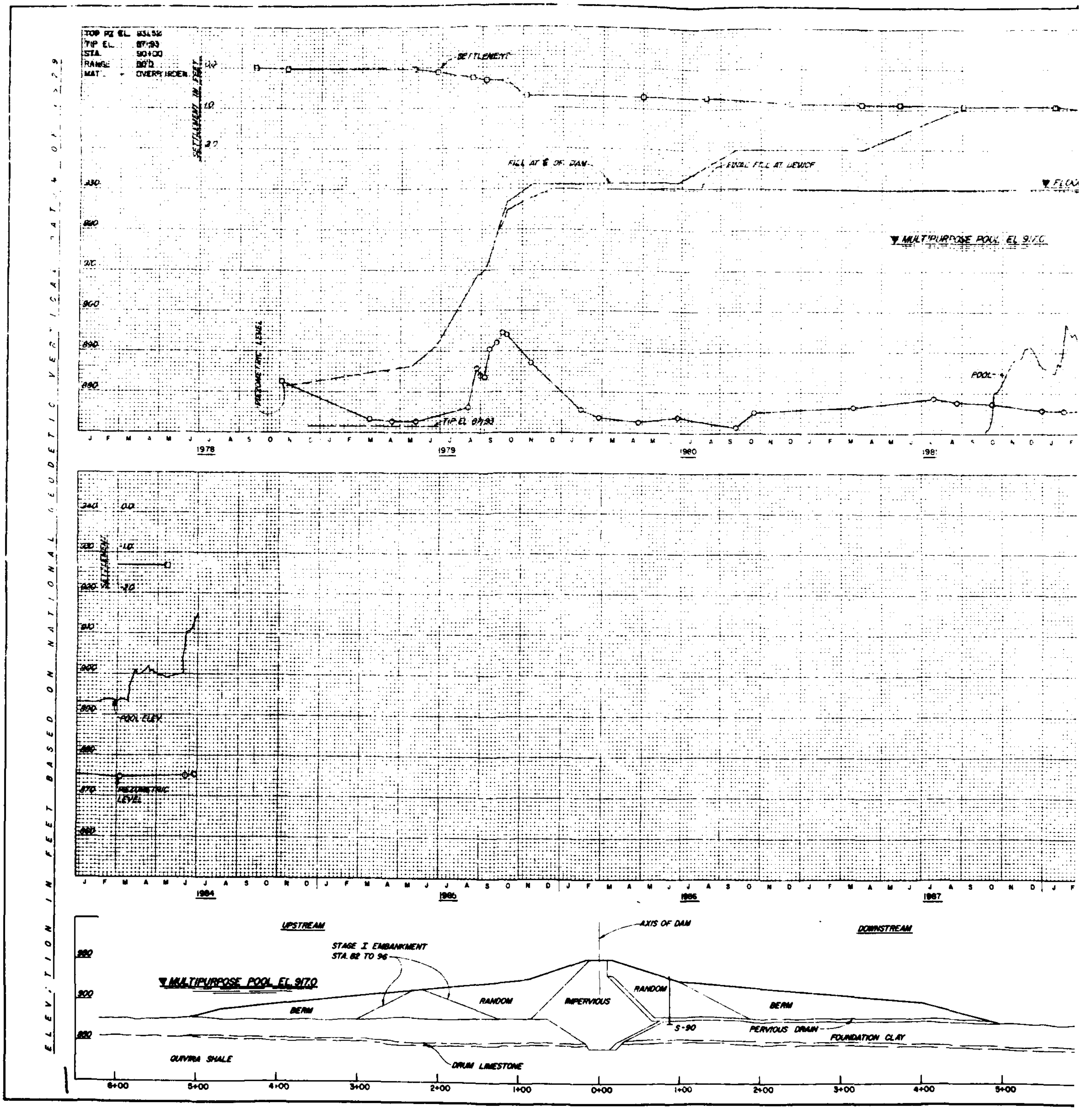
KANSAS CITY DISTRICT

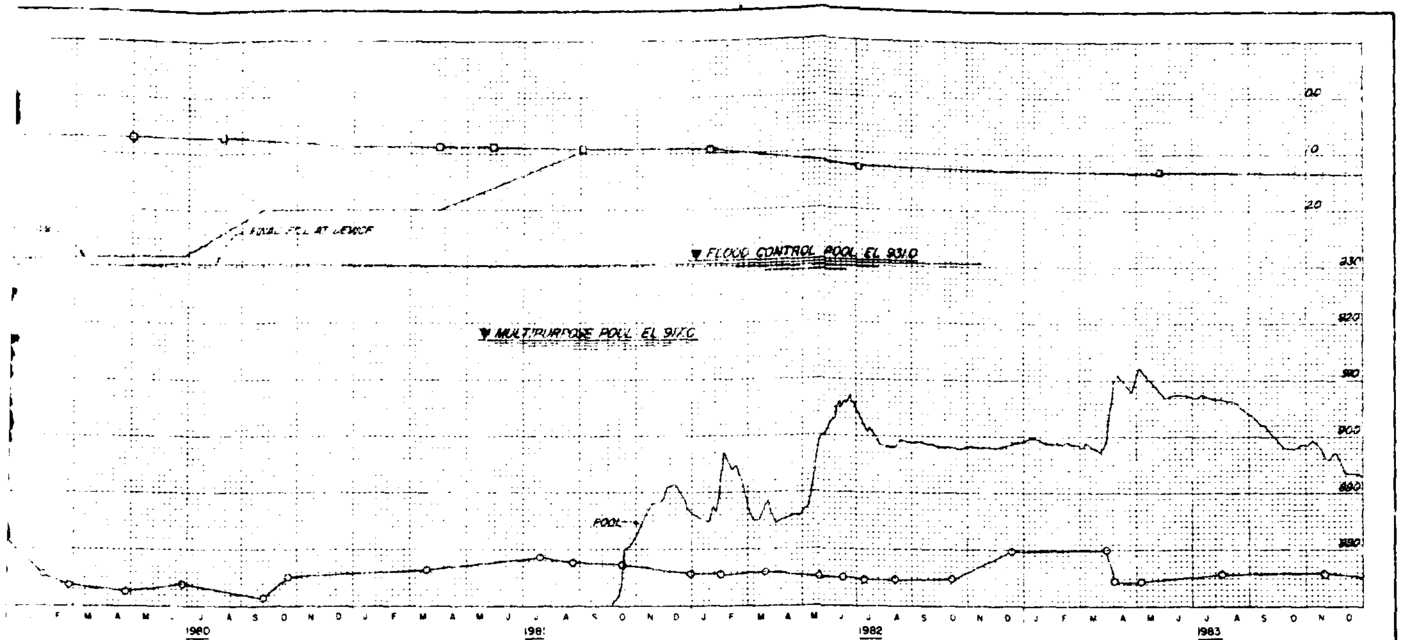
FILE NO. O-15-922

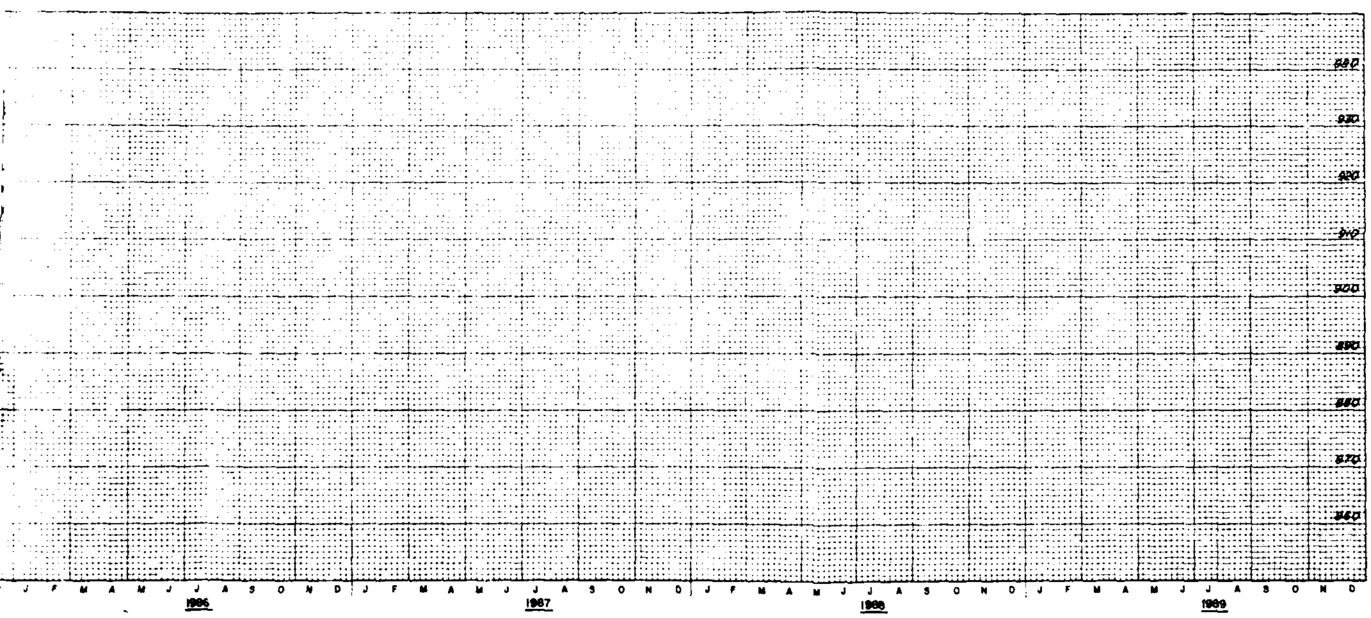
JANUARY 1983

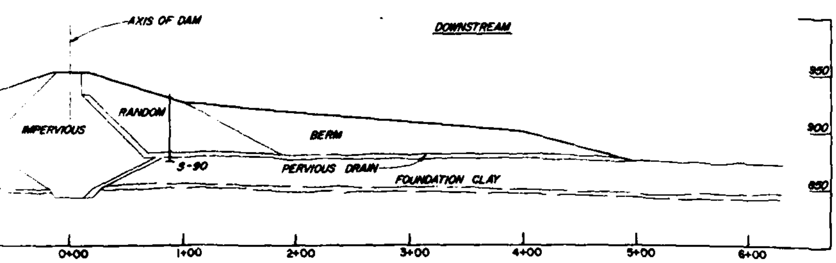
2

PLATE NO. 193


TOP PZ EL. 834.52
TIP EL. 871.93
STA. 90+00
RANGE 80'D
MAT. OVERBURDEN
SETTLEMENT IN FEET
SETTLEMENT
FILL AT ℄ OF DAM
FINAL FILL AT DEVICE
MULTIPURPOSE POOL EL 917.0
PIEZOMETRIC LEVEL
TIP EL 871.93
POOL
1978
1979
1980
1981
POOL ELEV.
1984
1985
1986
1987
ELEVATION IN FEET BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929
UPSTREAM
DOWNSTREAM
AXIS OF DAM
STAGE I EMBANKMENT STA. 82 TO 96
MULTIPURPOSE POOL EL 917.0
RANDOM
IMPERVIOUS
BERM
S-90
PERVIOUS DRAIN
FOUNDATION CLAY
QUIVIRA SHALE
DRUM LIMESTONE
6+00
5+00
4+00
3+00
2+00
1+00
0+00







REVISED SEPTEMBER 1984
BIG BULL CREEK, KANSAS

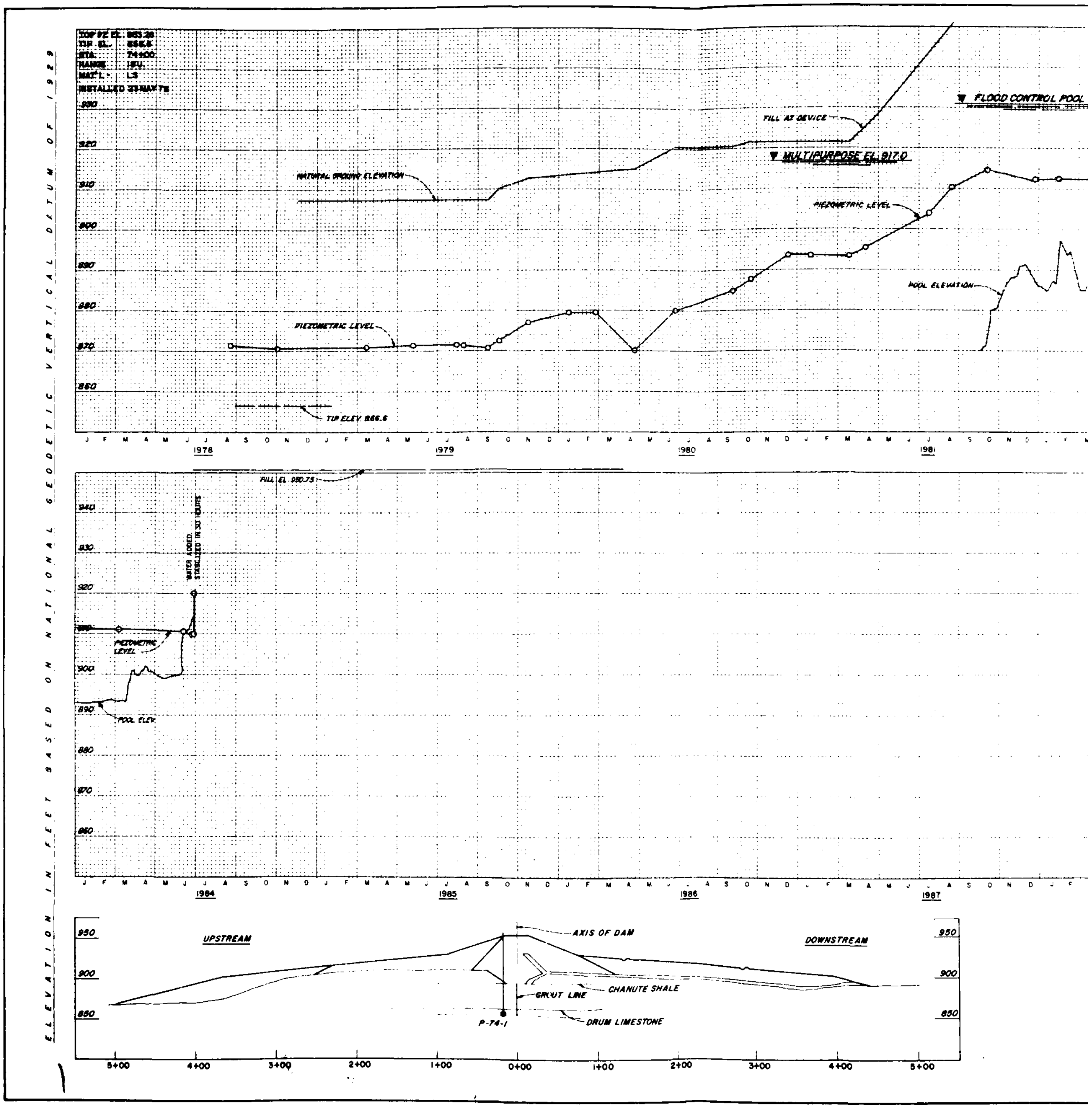
HILLSDALE LAKE

EMBANKMENT CRITERIA REPORT

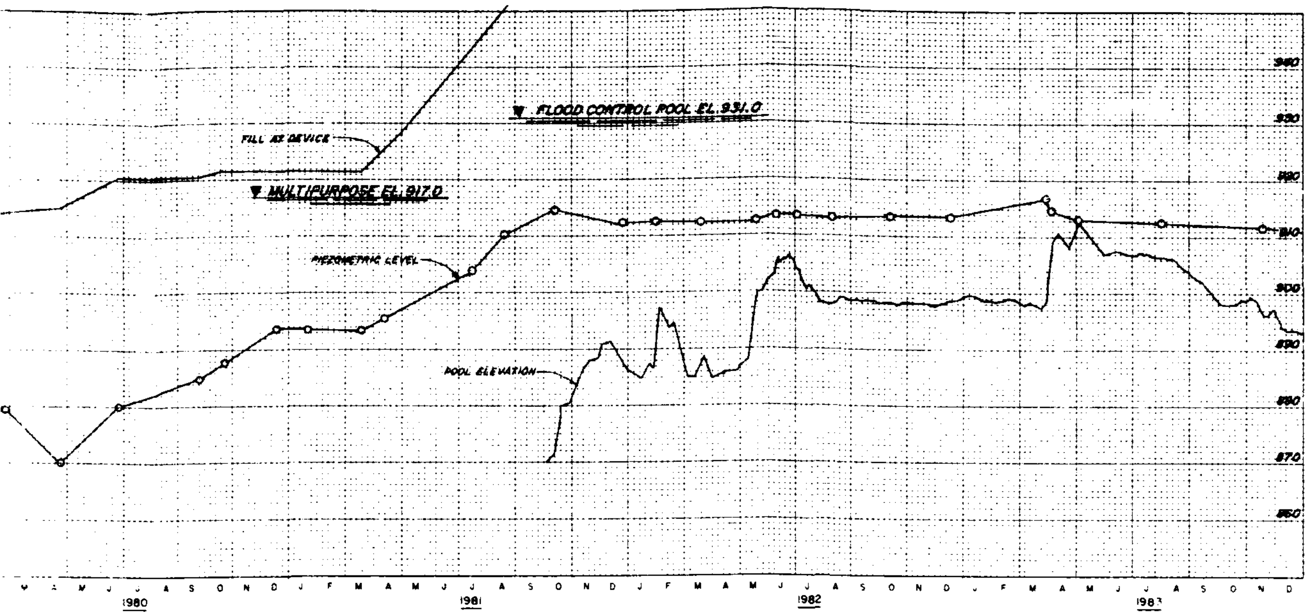
FOUNDATION SETTLEMENT PLATE AND OPEN TUBE PIEZOMETER
S-90

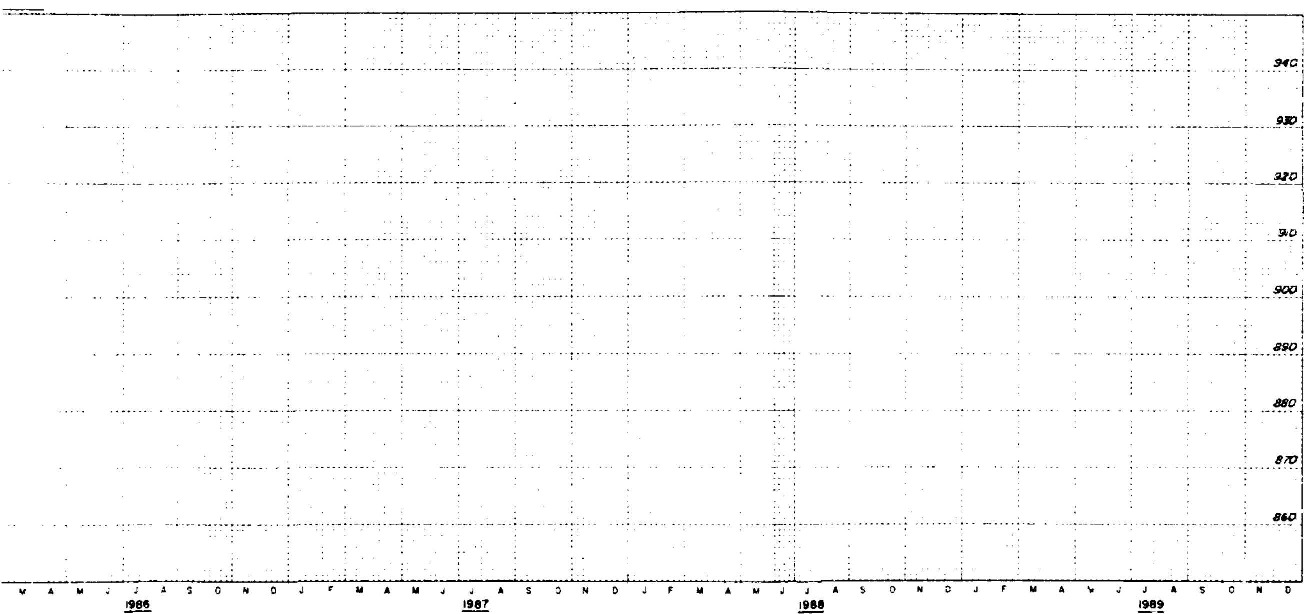
In 1 sheet   Sheet No. 1   Scale: as shown

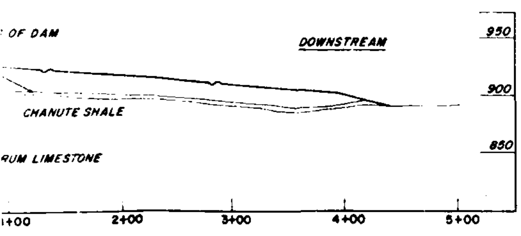
CORPS OF ENGINEERS   U. S. ARMY
KANSAS CITY DISTRICT
FILE NO. 0-15-923
JANUARY 1983



ELEVATION IN FEET BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929
STA. 74+00
MAT'L. LS
FLOOD CONTROL POOL
MULTIPURPOSE EL. 917.0
FILL AT DEVICE
NATURAL GROUND ELEVATION
PIEZOMETRIC LEVEL
POOL ELEVATION
TIP ELEV. 866.6
1978
1979
1980
1981
FILL EL. 950.75
WATER ADDED
STABILIZED IN 30 HOURS
PIEZOMETRIC LEVEL
POOL ELEV.
1984
1985
1986
1987
UPSTREAM
AXIS OF DAM
DOWNSTREAM
GROUT LINE
CHANUTE SHALE
DRUM LIMESTONE
P-74-1
5+00
4+00
3+00
2+00
1+00
0+00







REVISED SEPTEMBER 1984
BIG BULL CREEK, KANSAS

HILLSDALE LAKE

EMBANKMENT CRITERIA REPORT

OPEN TUBE PIEZOMETER
P-74-1

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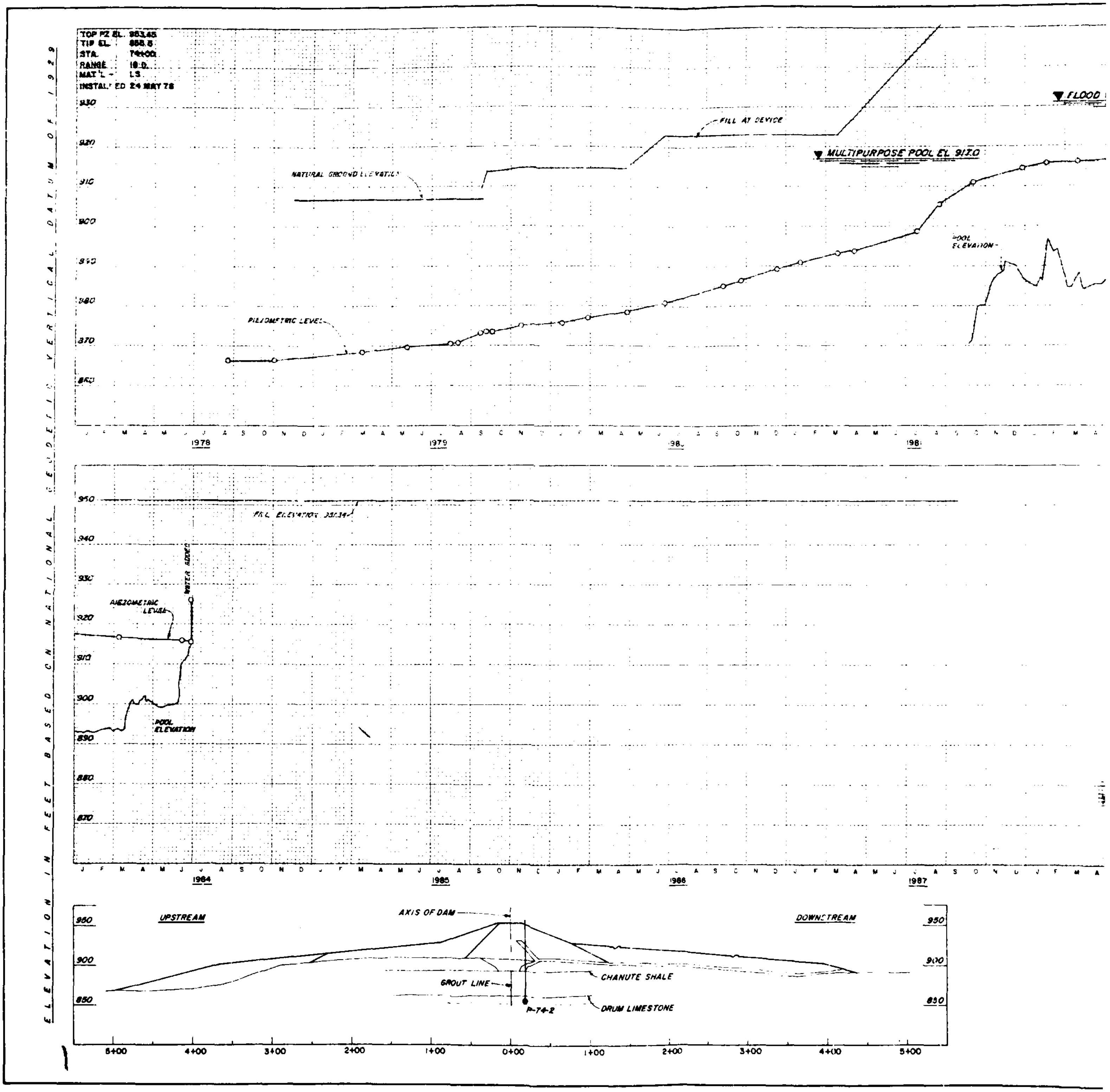
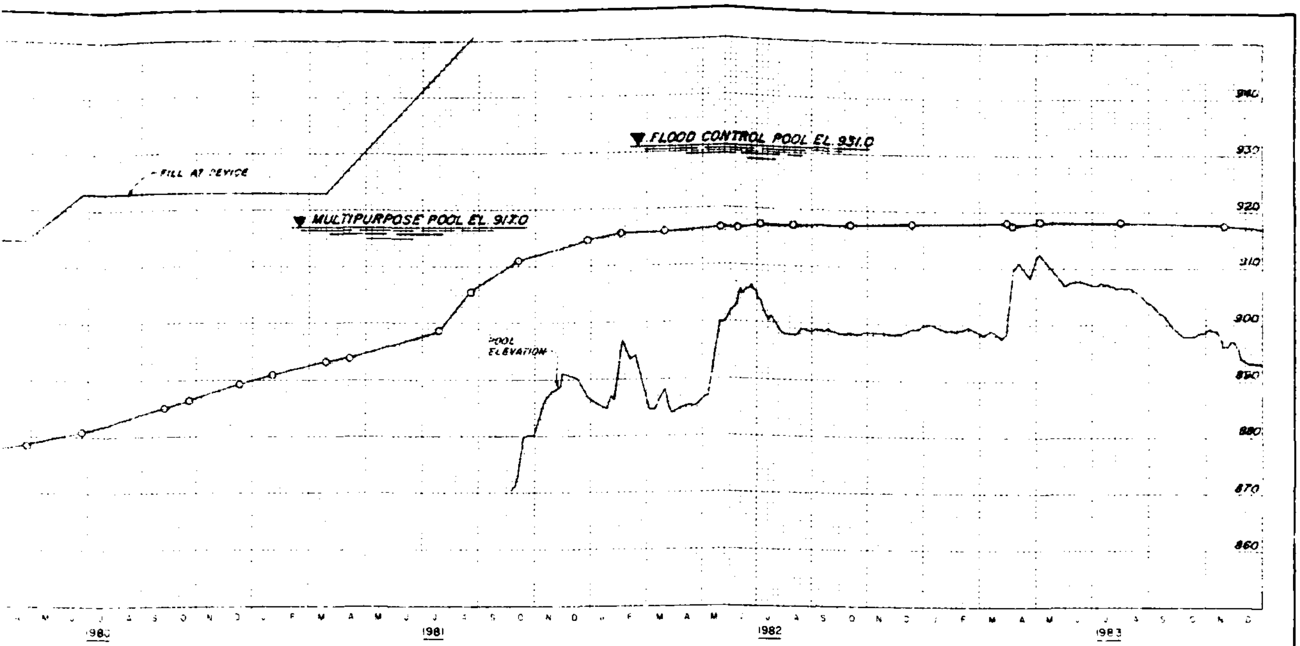
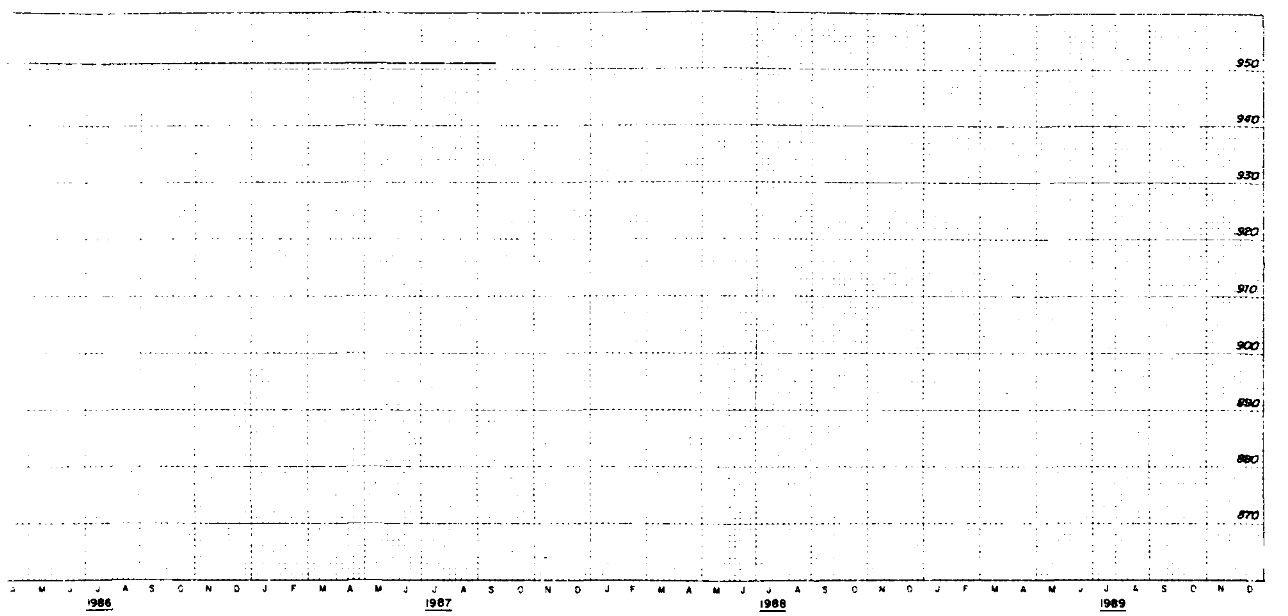
KANSAS CITY DISTRICT
FILE NO. 0-15-928
JANUARY 1983

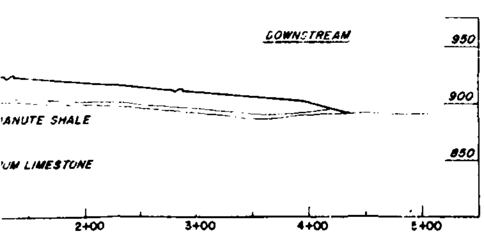
2

PLATE NO. 199


ELEVATION IN FEET BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929
TOP PZ EL. 963.45
TIP EL. 858.8
STA. 74+00
RANGE 18 D.
MAT'L - LS
INSTALLED 24 MAY 78
FILL AT DEVICE
NATURAL GROUND ELEVATION
MULTIPURPOSE POOL EL 917.0
FLOOD
POOL ELEVATION
PIEZOMETRIC LEVEL
1978
1979
1981
FILL ELEVATION
PIEZOMETRIC LEVEL
WATER ADDED
POOL ELEVATION
1984
1985
1986
1987
AXIS OF DAM
UPSTREAM
DOWNSTREAM
CHANUTE SHALE
GROUT LINE
DRUM LIMESTONE
P-74-2







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BIG BULL CREEK, KANSAS

HILLSDALE LAKE

EMBANKMENT CRITERIA REPORT

OPEN TUBE PIEZOMETER
P-74-2

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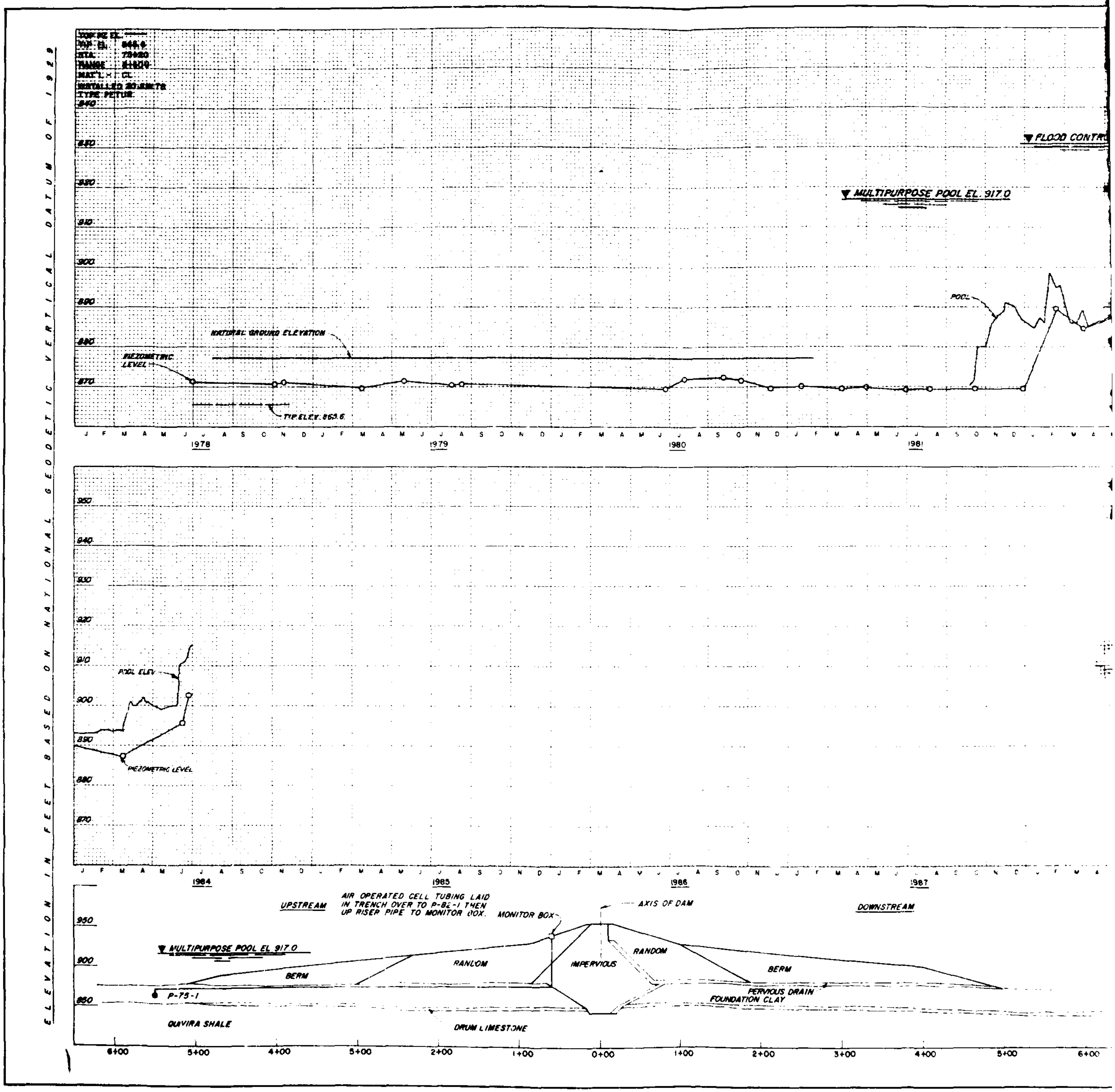
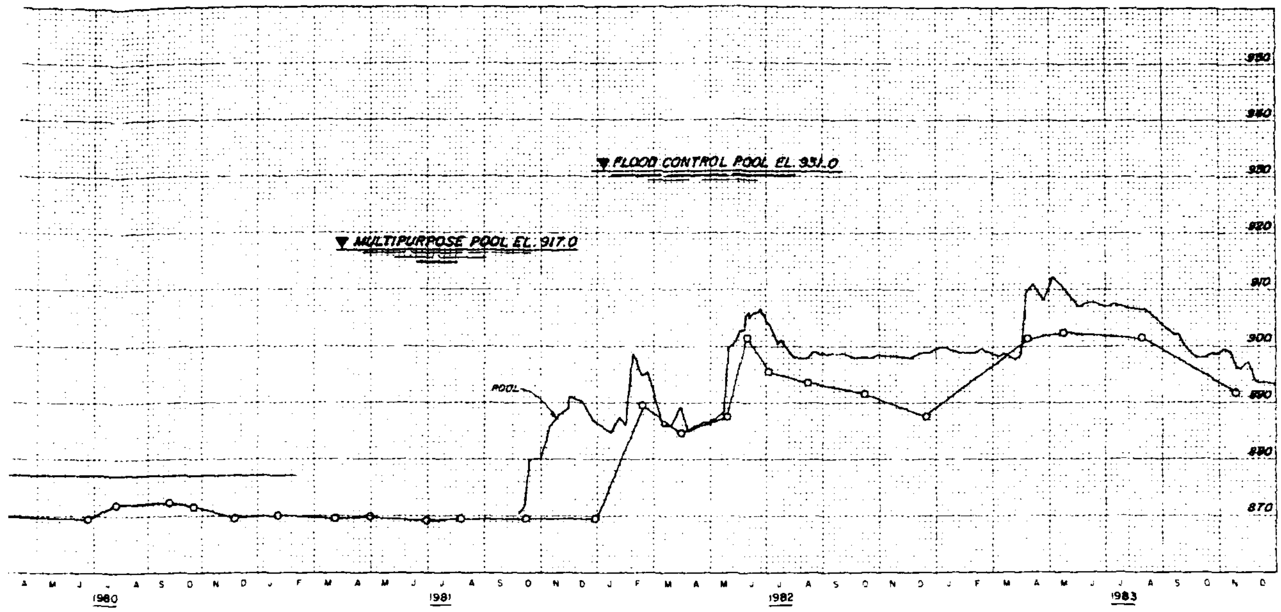
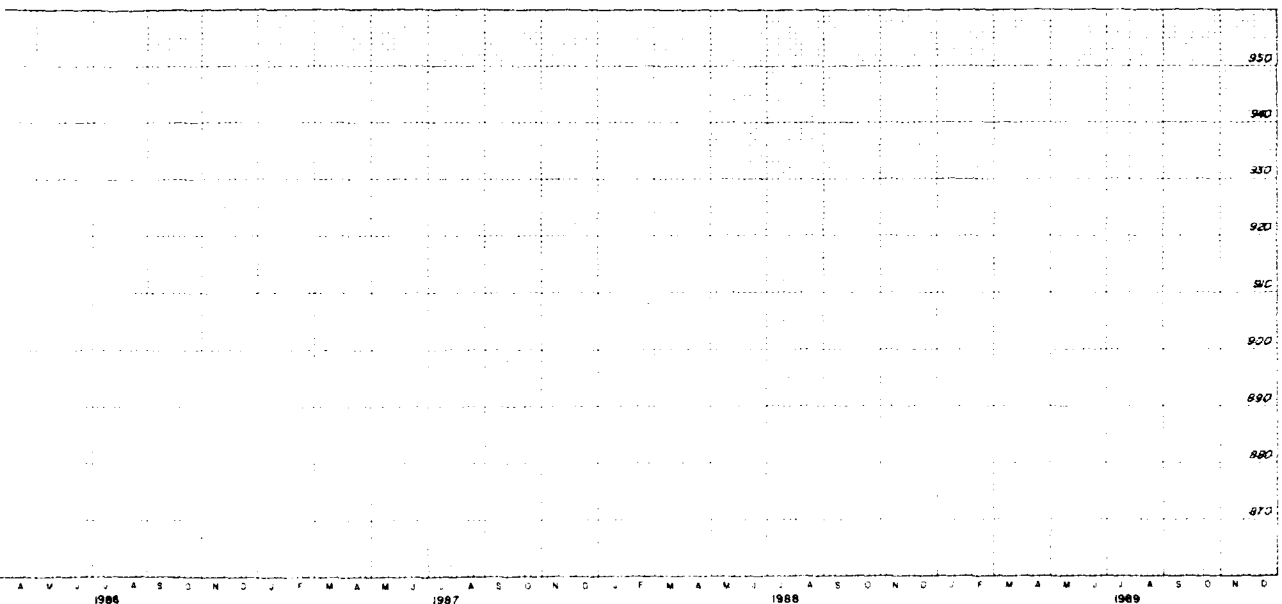
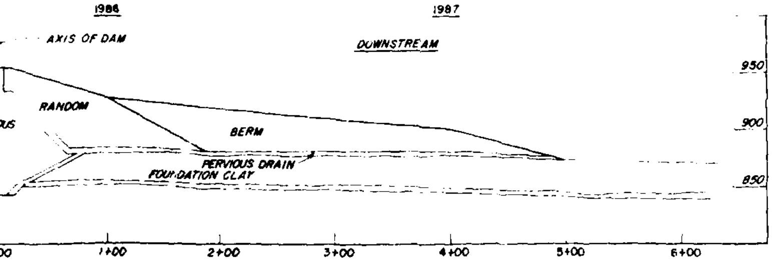
CORPS OF ENGINEERS U. S. ARMY
KANSAS CITY DISTRICT
FILE NO. 0-15-929
JANUARY 1983

PLATE NO 200


ELEVATION IN FEET BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929
MAT'L - CL
TYPE PETUR
FLOOD CONTR
MULTIPURPOSE POOL EL. 917.0
POOL
NATURAL GROUND ELEVATION
PIEZOMETRIC LEVEL
TIP ELEV. 863.6
1978
1979
1980
1981
POOL ELEV.
PIEZOMETRIC LEVEL
1984
1985
1986
1987
UPSTREAM
AIR OPERATED CELL TUBING LAID IN TRENCH OVER TO P-82-1 THEN UP RISER PIPE TO MONITOR BOX.
MONITOR BOX
AXIS OF DAM
DOWNSTREAM
MULTIPURPOSE POOL EL. 917.0
RANDOM
IMPERVIOUS
RANDOM
BERM
BERM
P-75-1
PERVIOUS DRAIN
FOUNDATION CLAY
QUIVIRA SHALE
DRUM LIMESTONE
6+00
5+00
4+00
3+00
2+00
1+00
0+00
1+00
2+00
3+00
4+00
5+00
6+00







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BIG BULL CREEK, KANSAS

HILLSDALE LAKE

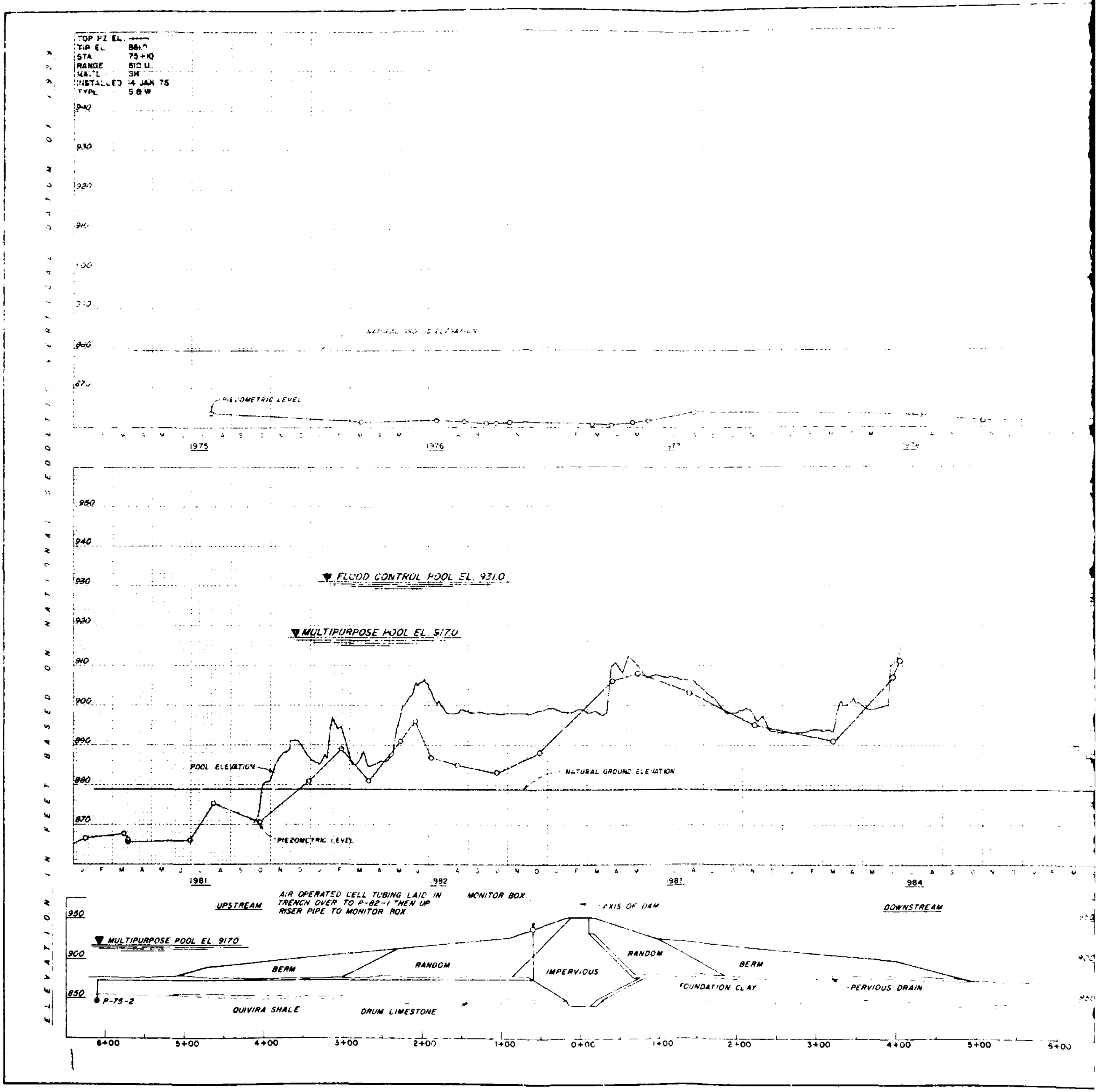
EMBANKMENT CRITERIA REPORT

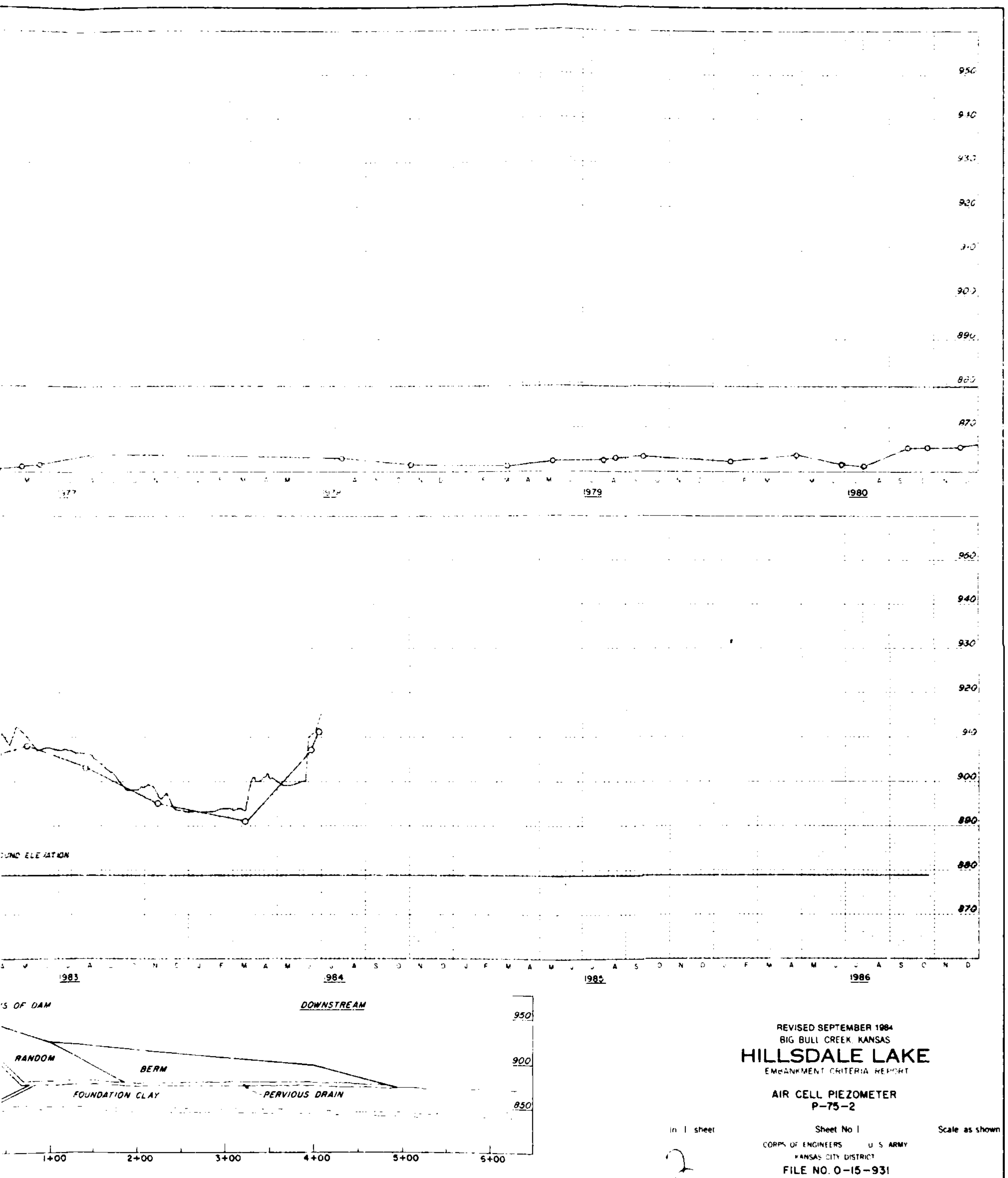
AIR CELL PIEZOMETER
P-75-1

In 1 sheet | Sheet No. 1 | Scale: as shown

CORPS OF ENGINEERS U. S. ARMY
KANSAS CITY DISTRICT
FILE NO. 0-15-930
JANUARY 1983

2


TOP PZ EL.
TIP EL. 861.0
STA 75+10
RANGE 610 U.
MAT'L SH
INSTALLED 14 JAN 75
TYPE S & W
PIEZOMETRIC LEVEL
1975
1976
FLOOD CONTROL POOL EL. 931.0
MULTIPURPOSE POOL EL. 917.0
POOL ELEVATION
NATURAL GROUND ELEVATION
PIEZOMETRIC LEVEL
1981
1982
1983
1984
UPSTREAM
AIR OPERATED CELL TUBING LAID IN TRENCH OVER TO P-82-1 THEN UP RISER PIPE TO MONITOR BOX.
MONITOR BOX
AXIS OF DAM
DOWNSTREAM
MULTIPURPOSE POOL EL. 917.0
BERM
RANDOM
IMPERVIOUS
RANDOM
BERM
FOUNDATION CLAY
PERVIOUS DRAIN
P-75-2
QUIVIRA SHALE
DRUM LIMESTONE
6+00
5+00
4+00
3+00
2+00
1+00
0+00
1+00
2+00
3+00
4+00
5+00
5+00
ELEVATION IN FEET BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929



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BIG BULL CREEK, KANSAS

HILLSDALE LAKE

EMBANKMENT CRITERIA REPORT

AIR CELL PIEZOMETER
P-75-2

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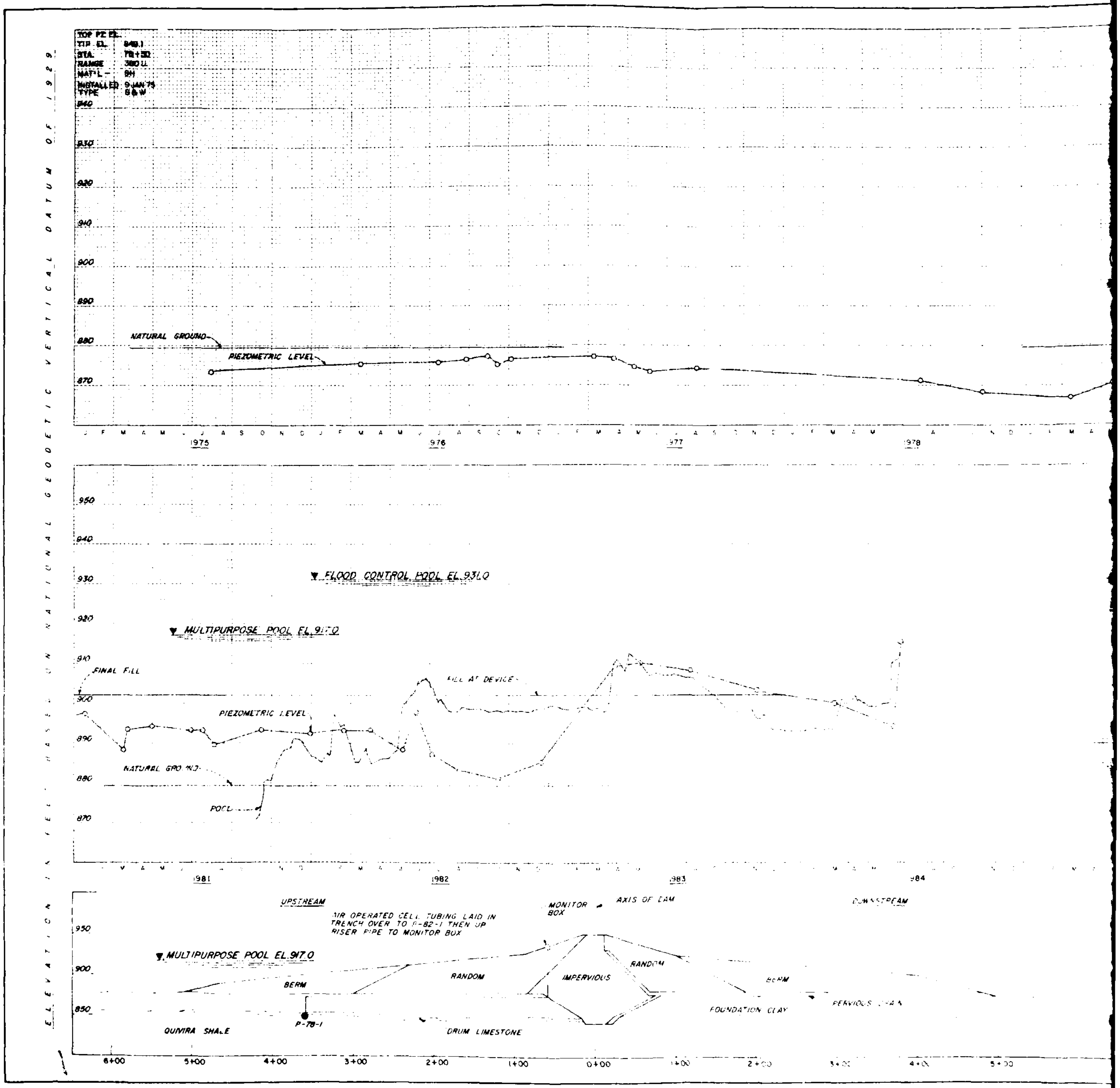
CORPS OF ENGINEERS U. S. ARMY
KANSAS CITY DISTRICT
FILE NO. 0-15-931
JANUARY 1983

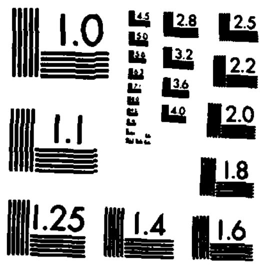
PLATE NO 202


TOP PZ EL.
TIP EL.
STA.
RANGE
MAT'L
INSTALLED 9 JAN 75
TYPE
NATURAL GROUND
PIEZOMETRIC LEVEL
1975
1976
1977
1978
FLOOD CONTROL POOL EL 931.0
MULTIPURPOSE POOL EL 917.0
FINAL FILL
PIEZOMETRIC LEVEL
POOL
1981
1982
UPSTREAM
AIR OPERATED CELL TUBING LAID IN TRENCH OVER TO P-82-1 THEN UP RISER PIPE TO MONITOR BOX
MONITOR BOX
AXIS OF DAM
MULTIPURPOSE POOL EL.917.0
BERM
RANDOM
IMPERVIOUS
RANDOM
BERM
FOUNDATION CLAY
P-78-1
QUIVIRA SHALE
DRUM LIMESTONE
6+00
5+00
4+00
3+00
2+00
1+00
0+00
2+00
4+00
5+00
ELEVATION IN FEET NATIONAL GEODETIC VERTICAL DATUM OF 1929

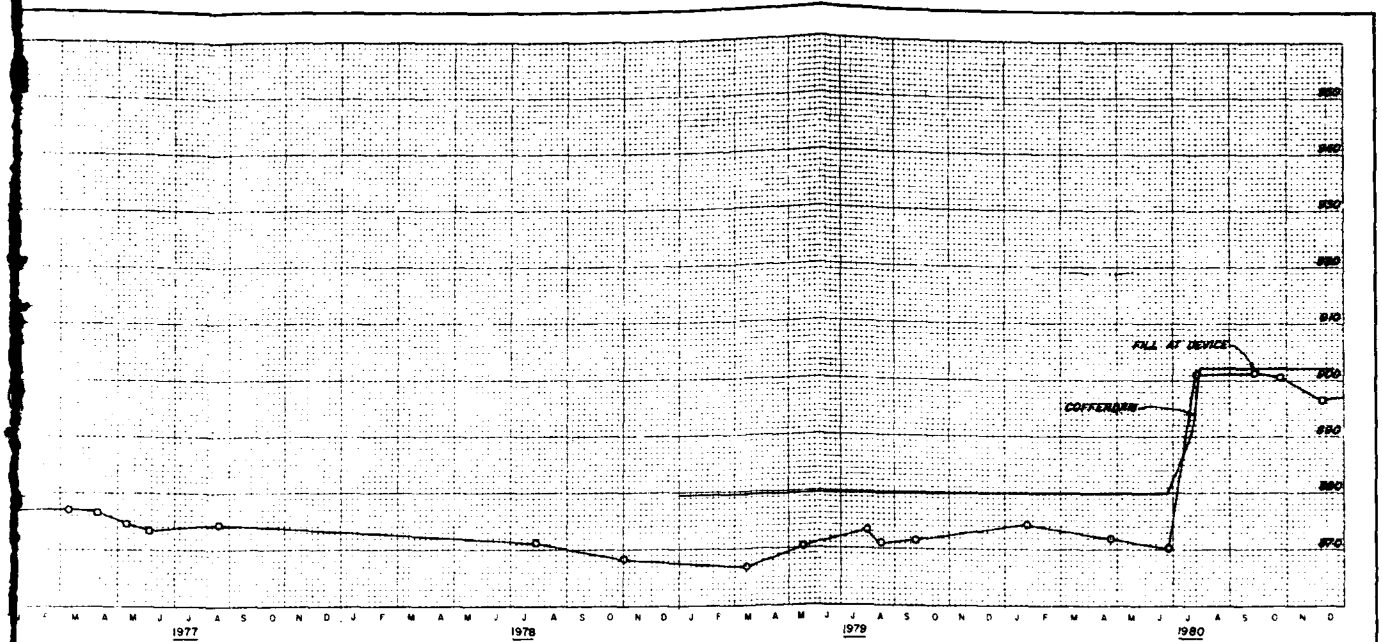
AD-A169 863 MULTIPLE-PURPOSE PROJECT OSAGE RIVER BASIN BIG BULL CREEK KANSAS HILLSDAL..(U) CORPS OF ENGINEERS KANSAS CITY MO KANSAS CITY DISTRICT F C WALBERG ET AL. SEP 84 4/4

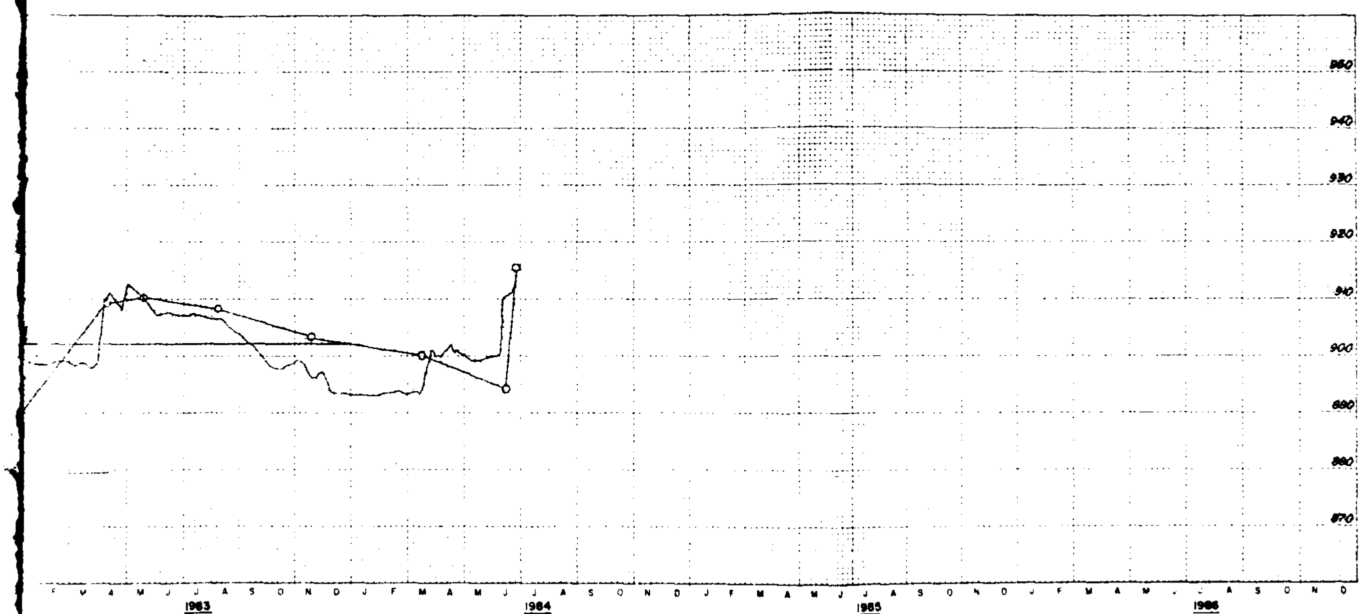
UNCLASSIFIED F/G 13/2 NL

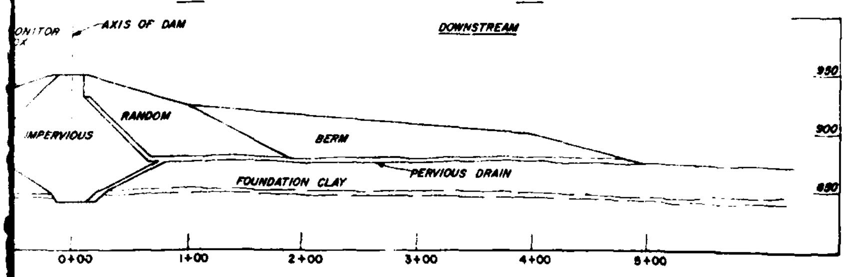
END
DATE
FILMED
8 86



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A







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BIG BULL CREEK, KANSAS

HILLSDALE LAKE

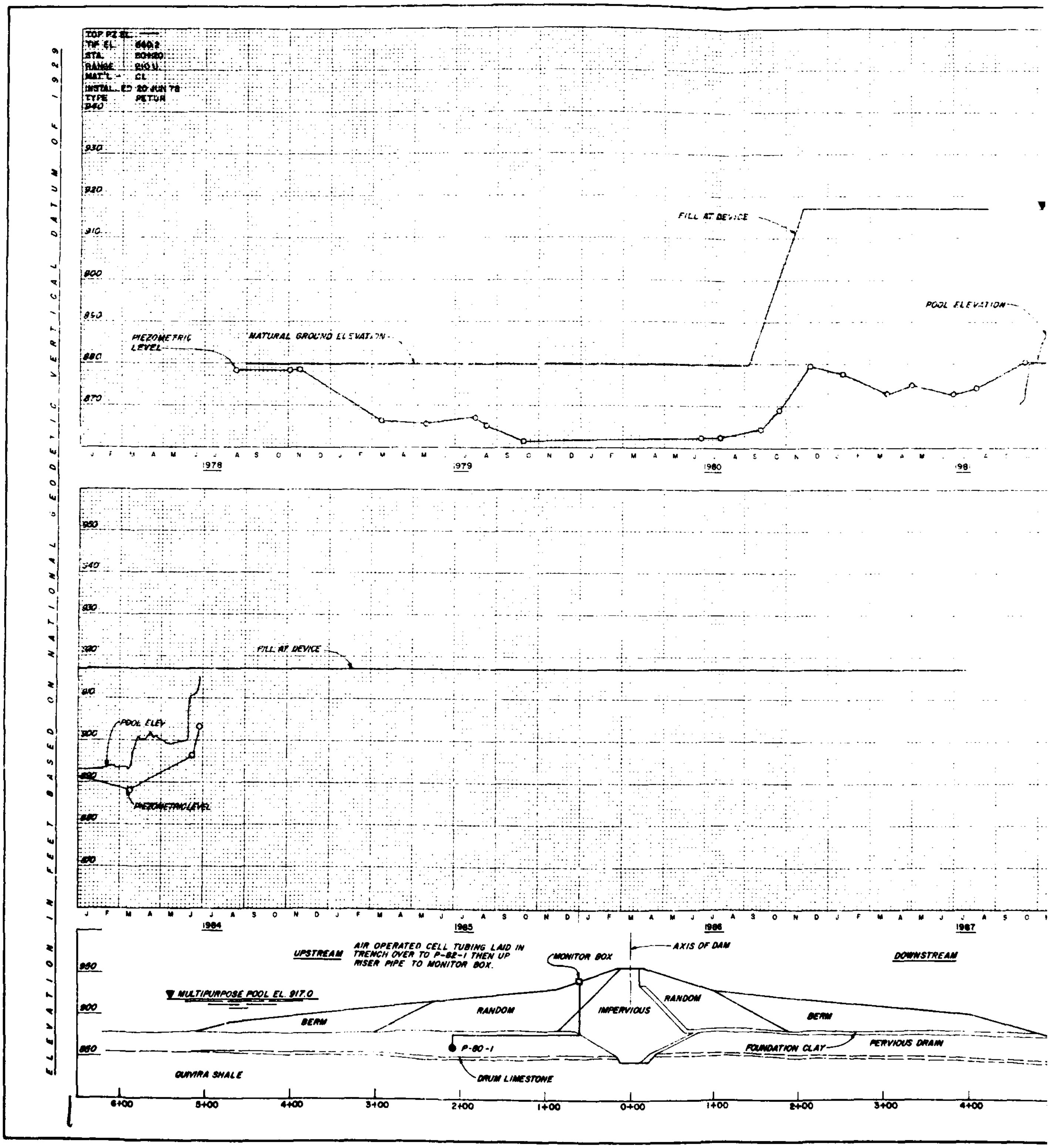
EMBANKMENT CRITERIA REPORT

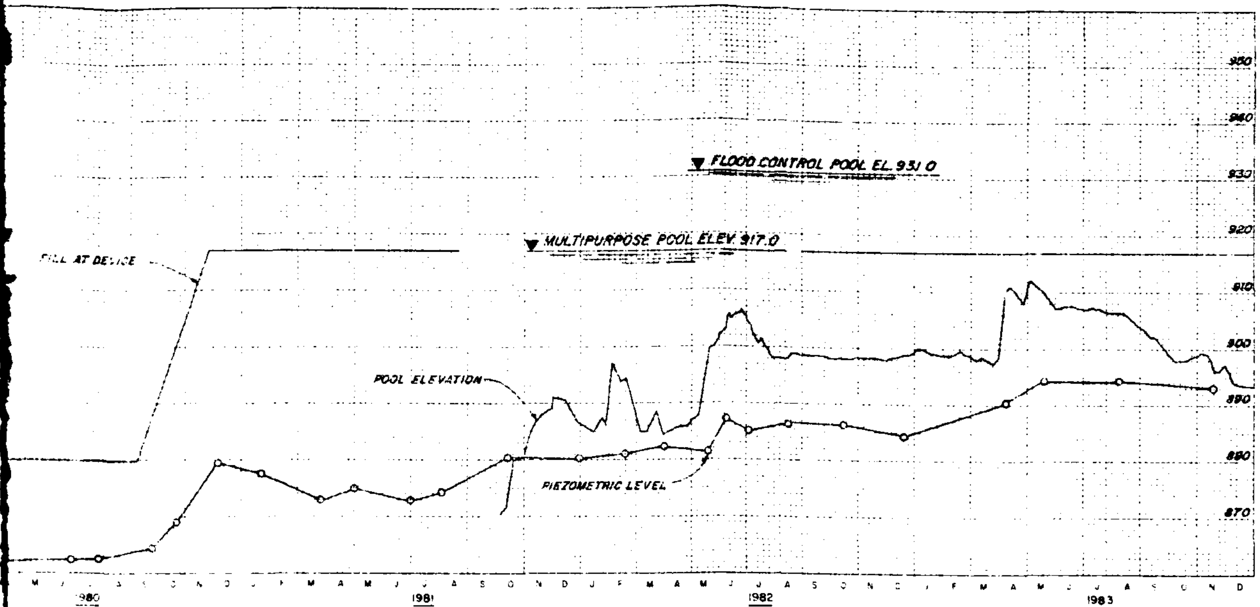
AIR CELL PIEZOMETER
P-78-1

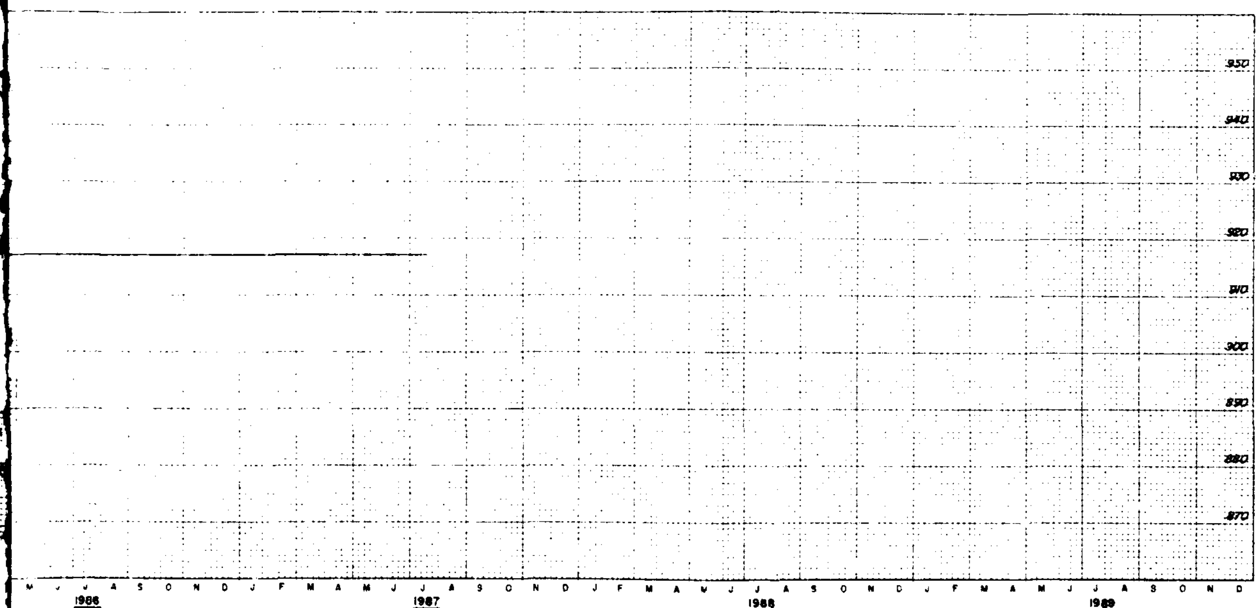
In 1 sheet | Sheet No. 1 | Scale: as shown

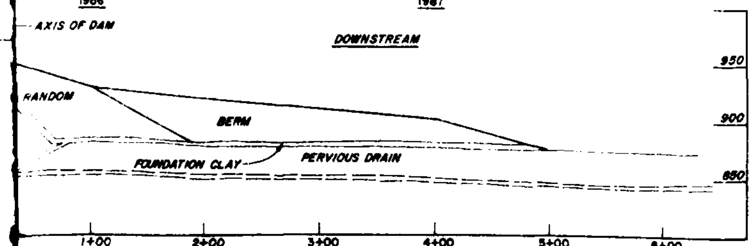
CORPS OF ENGINEERS U. S. ARMY
KANSAS CITY DISTRICT
FILE NO. O-15-932
JANUARY 1983

PLATE NO 203


ELEVATION IN FEET BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929
TOP PZ EL.
TIP EL.
STA.
RANGE
MAT'L - CL
INSTALLED 20 JUN 78
TYPE PETUR
FILL AT DEVICE
POOL ELEVATION
PIEZOMETRIC LEVEL
NATURAL GROUND ELEVATION
1978
1979
1980
FILL AT DEVICE
POOL ELEV
PIEZOMETRIC LEVEL
1984
1985
1986
1987
UPSTREAM
AIR OPERATED CELL TUBING LAID IN TRENCH OVER TO P-82-1 THEN UP RISER PIPE TO MONITOR BOX.
MONITOR BOX
AXIS OF DAM
DOWNSTREAM
MULTIPURPOSE POOL EL. 917.0
RANDOM
IMPERVIOUS
RANDOM
BERM
BERM
P-80-1
FOUNDATION CLAY
PERVIOUS DRAIN
QUIVIRA SHALE
DRUM LIMESTONE
6+00
5+00
4+00
3+00
2+00
1+00
0+00
1+00
2+00
3+00
4+00







REVISED SEPTEMBER 1984
BIG BULL CREEK, KANSAS

HILLSDALE LAKE

EMBANKMENT CRITERIA REPORT

AIR CELL PIEZOMETER P-80-1

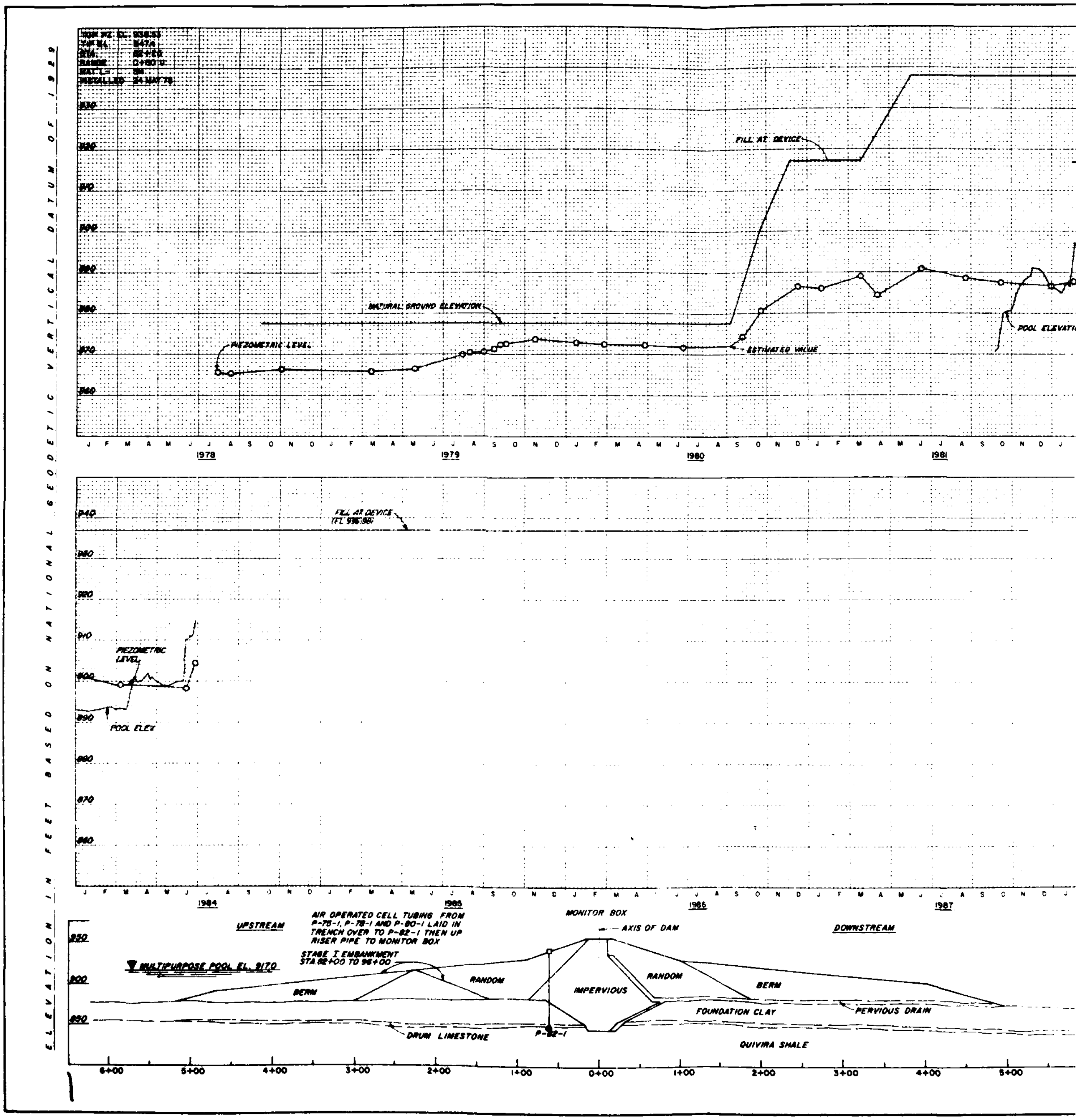
In 1 sheet — Sheet No. 1 — Scale: as shown

CORPS OF ENGINEERS U. S. ARMY
KANSAS CITY DISTRICT

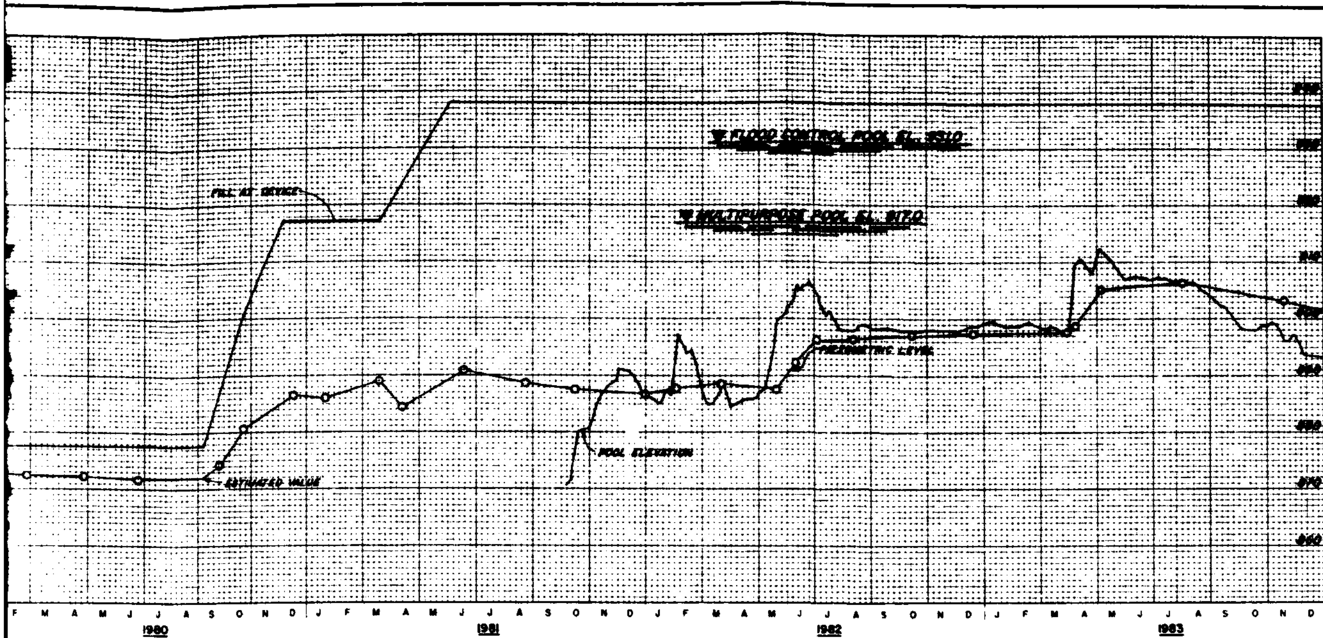
FILE NO. O-15-933
JANUARY 1983

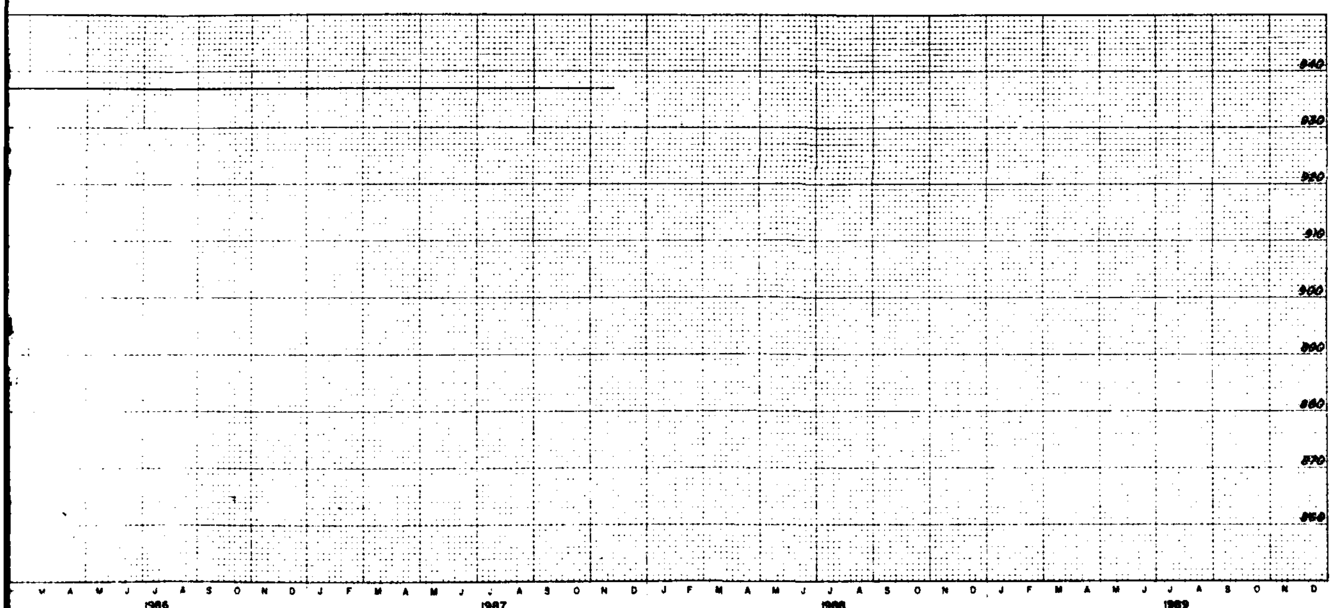
2

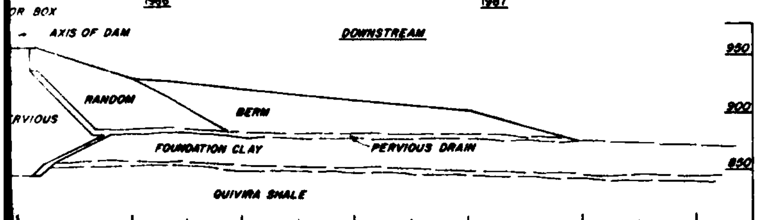
PLATE NO 204



ELEVATION IN FEET BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929
INSTALLED 24 MAY 78
FILL AT DEVICE
NATURAL GROUND ELEVATION
PIEZOMETRIC LEVEL
ESTIMATED VALUE
POOL ELEVATI
1978
1979
1980
1981
FILL AT DEVICE (EL 936.98)
PIEZOMETRIC LEVEL
POOL ELEV
1984
1985
1986
1987
UPSTREAM
AIR OPERATED CELL TUBING FROM P-75-1, P-78-1 AND P-80-1 LAID IN TRENCH OVER TO P-82-1 THEN UP RISER PIPE TO MONITOR BOX
MONITOR BOX
AXIS OF DAM
DOWNSTREAM
STAGE I EMBANKMENT STA 92+00 TO 96+00
MULTIPURPOSE POOL EL. 917.0
BERM
RANDOM
IMPERVIOUS
RANDOM
BERM
FOUNDATION CLAY
PERVIOUS DRAIN
DRUM LIMESTONE
P-82-1
QUIVIRA SHALE
6+00
5+00
4+00
3+00
2+00
1+00
0+00
1+00
2+00
3+00
4+00
5+00







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BIG BULL CREEK, KANSAS

HILLSDALE LAKE

EMBANKMENT CRITERIA REPORT

OPEN TUBE PIEZOMETER
P-82-1

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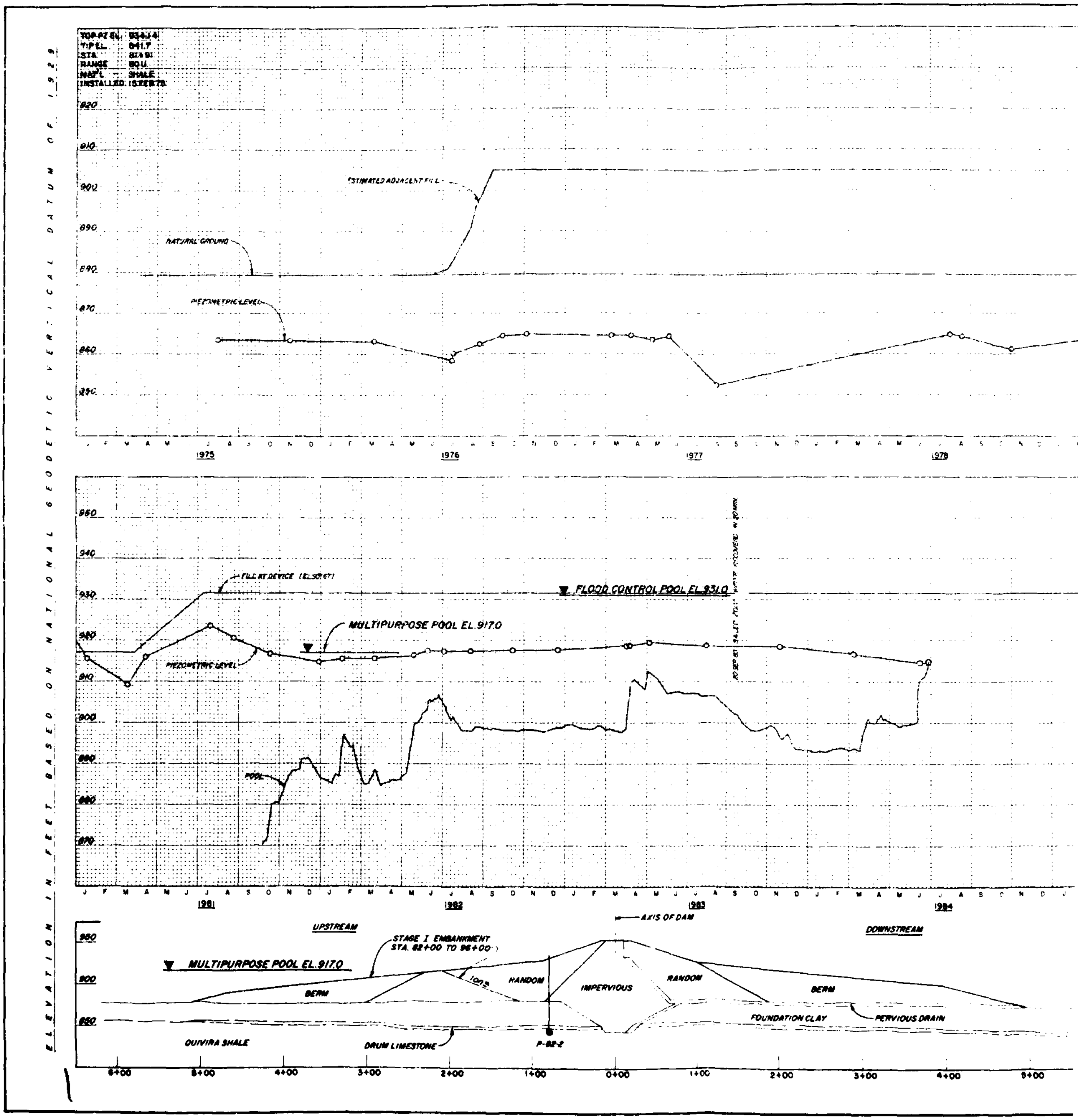
KANSAS CITY DISTRICT

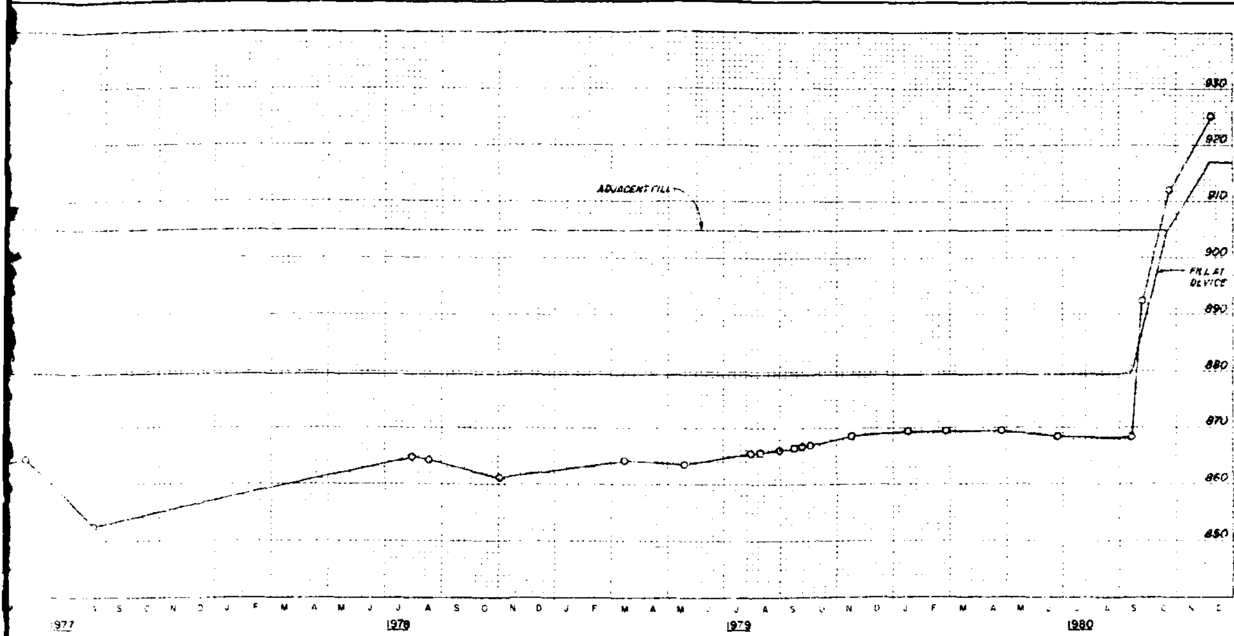
2

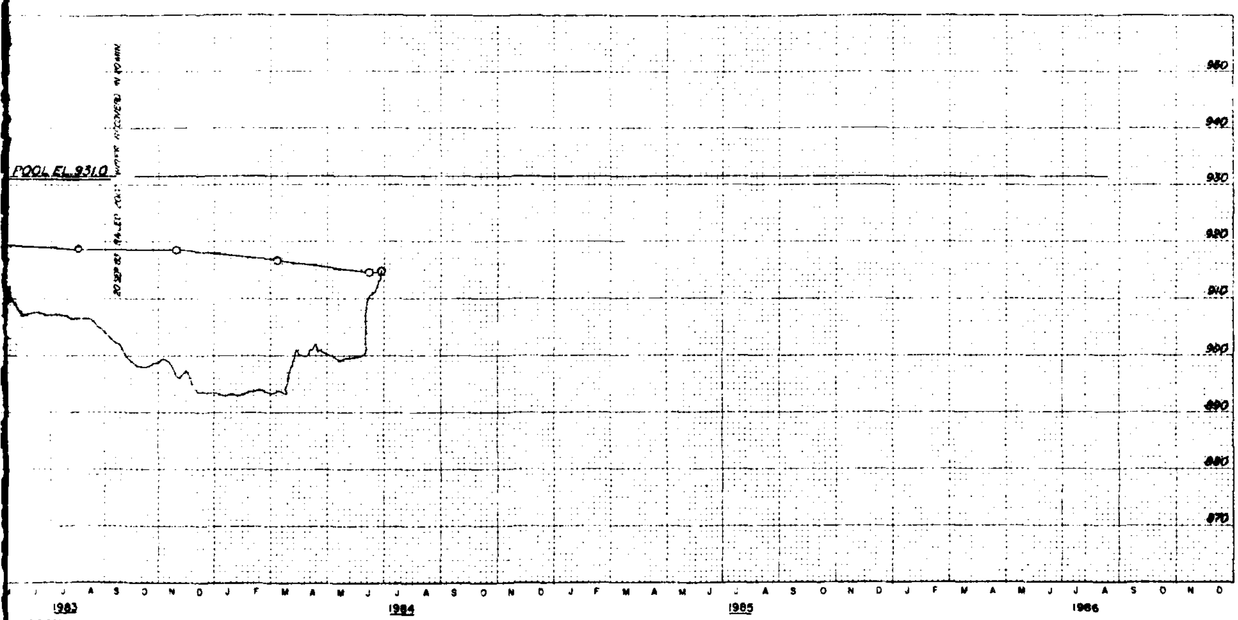
FILE NO. 0-15-934
JANUARY 1983

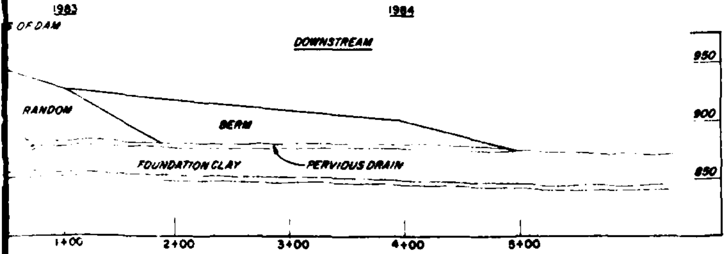
PLATE NO 205



ELEVATION IN FEET BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929
TOP PZ EL. 934.14
TIP EL. 841.7
STA. 81+91
RANGE 80 U
MAT'L SHALE
INSTALLED 15 FEB 75
ESTIMATED ADJACENT FILL
NATURAL GROUND
PIEZOMETRIC LEVEL
1975
1976
1977
1978
FILL AT DEVICE
FLOOD CONTROL POOL EL.931.0
MULTIPURPOSE POOL EL.917.0
PIEZOMETRIC LEVEL
POOL
1981
1982
1983
1984
UPSTREAM
AXIS OF DAM
DOWNSTREAM
STAGE I EMBANKMENT STA. 82+00 TO 96+00
MULTIPURPOSE POOL EL.917.0
BERM
RANDOM
IMPERVIOUS
RANDOM
BERM
FOUNDATION CLAY
PERVIOUS DRAIN
QUIVIRA SHALE
DRUM LIMESTONE
P-82-2







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EMBANKMENT CRITERIA REPORT

OPEN TUBE PIEZOMETER
P-82-2

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KANSAS CITY DISTRICT

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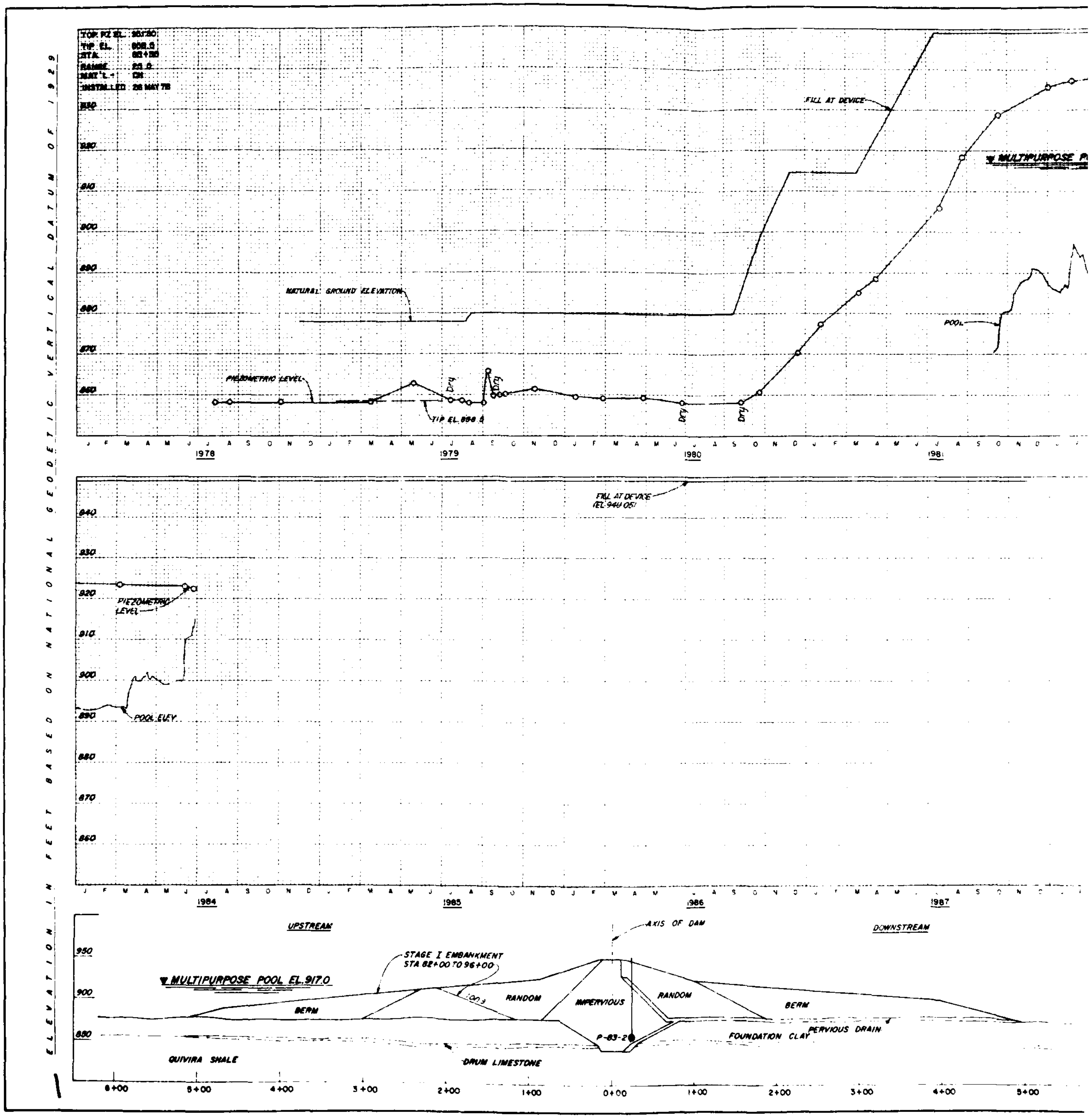
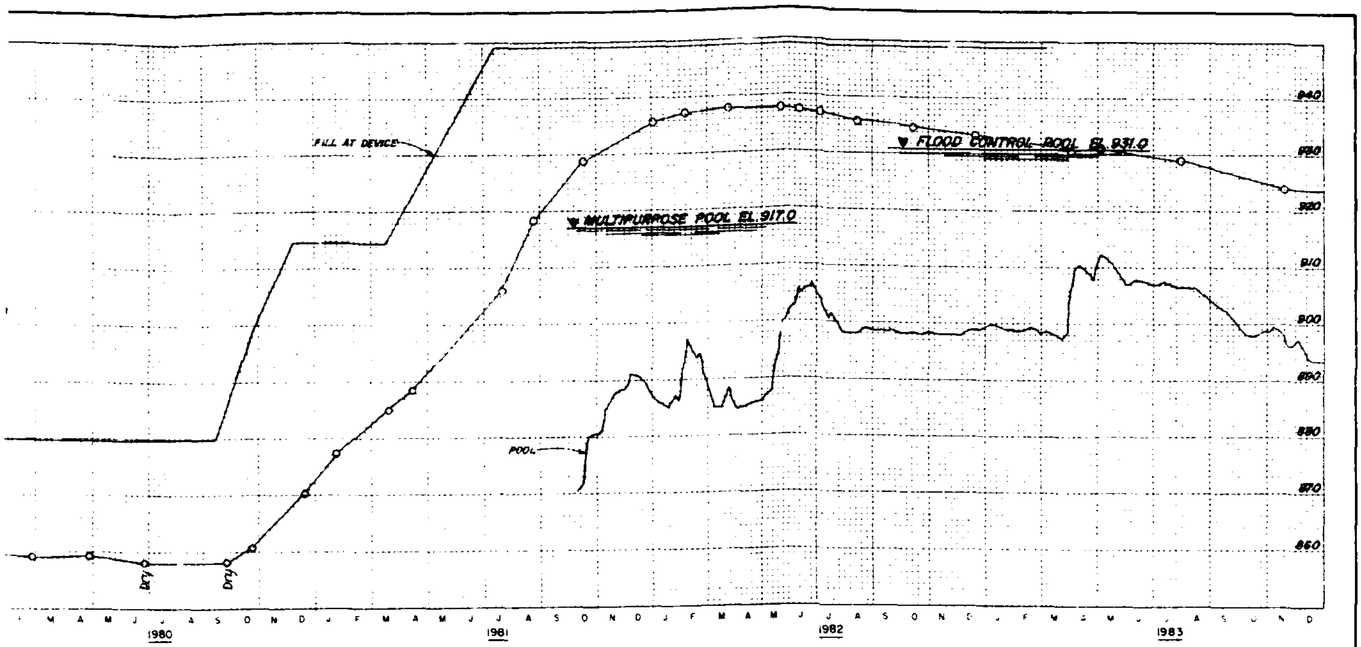
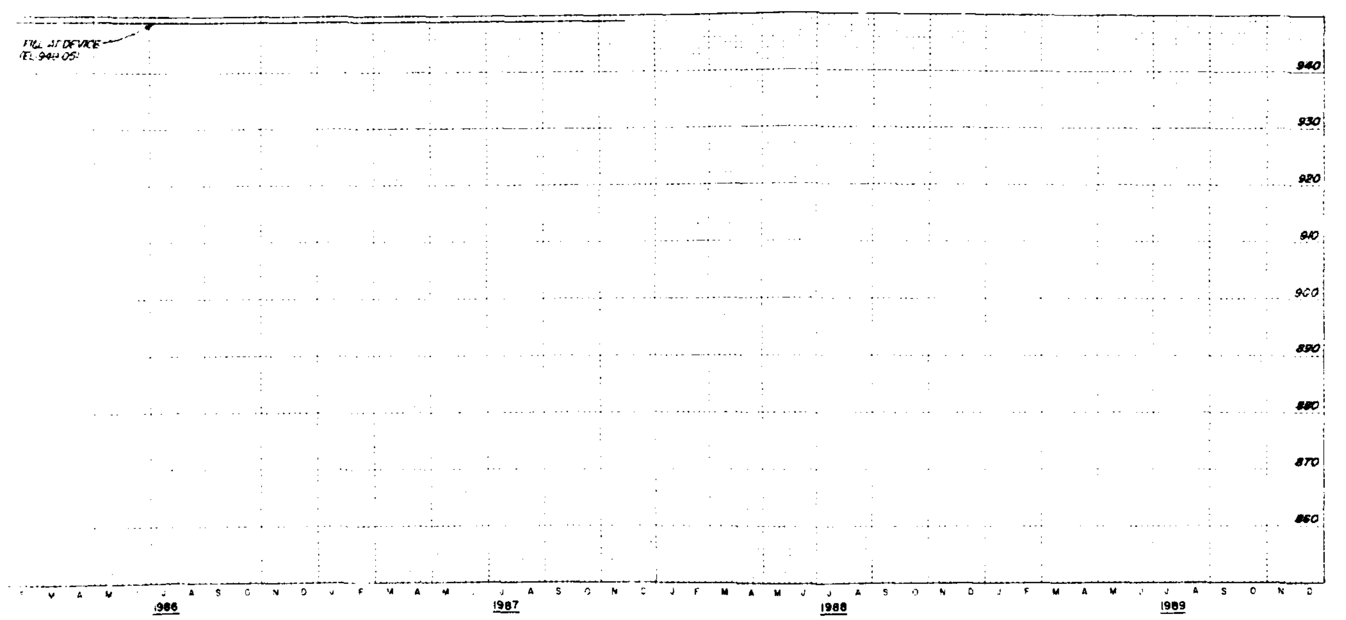
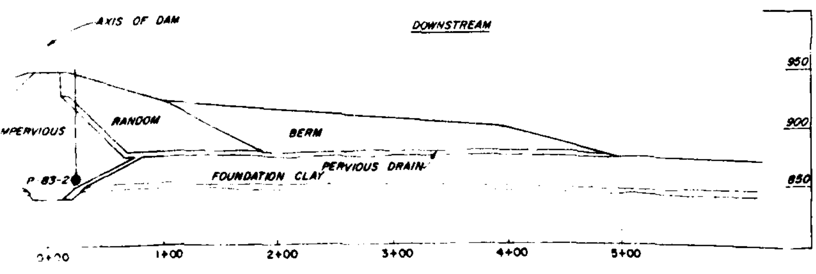
FILE NO. 0-15-935
JANUARY 1983

PLATE NO 206


ELEVATION IN FEET BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929
TOP PZ EL.
TIP EL.
STA.
RANGE
MAT'L.
INSTALLED
FILL AT DEVICE
MULTIPURPOSE P
NATURAL GROUND ELEVATION
POOL
PIEZOMETRIC LEVEL
Dry
TIP EL. 858.5
1978
1979
1980
1981
FILL AT DEVICE
(EL. 949.05)
PIEZOMETRIC LEVEL
POOL ELEV.
1984
1985
1986
1987
UPSTREAM
AXIS OF DAM
DOWNSTREAM
STAGE I EMBANKMENT
STA 82+00 TO 96+00
MULTIPURPOSE POOL EL. 917.0
BERM
RANDOM
IMPERVIOUS
RANDOM
BERM
P-83-2
FOUNDATION CLAY
PERVIOUS DRAIN
QUIVIRA SHALE
DRUM LIMESTONE
6+00
5+00
4+00
3+00
2+00
1+00
0+00
1+00
2+00
3+00
4+00
5+00







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OPEN TUBE PIEZOMETER
P-83-2

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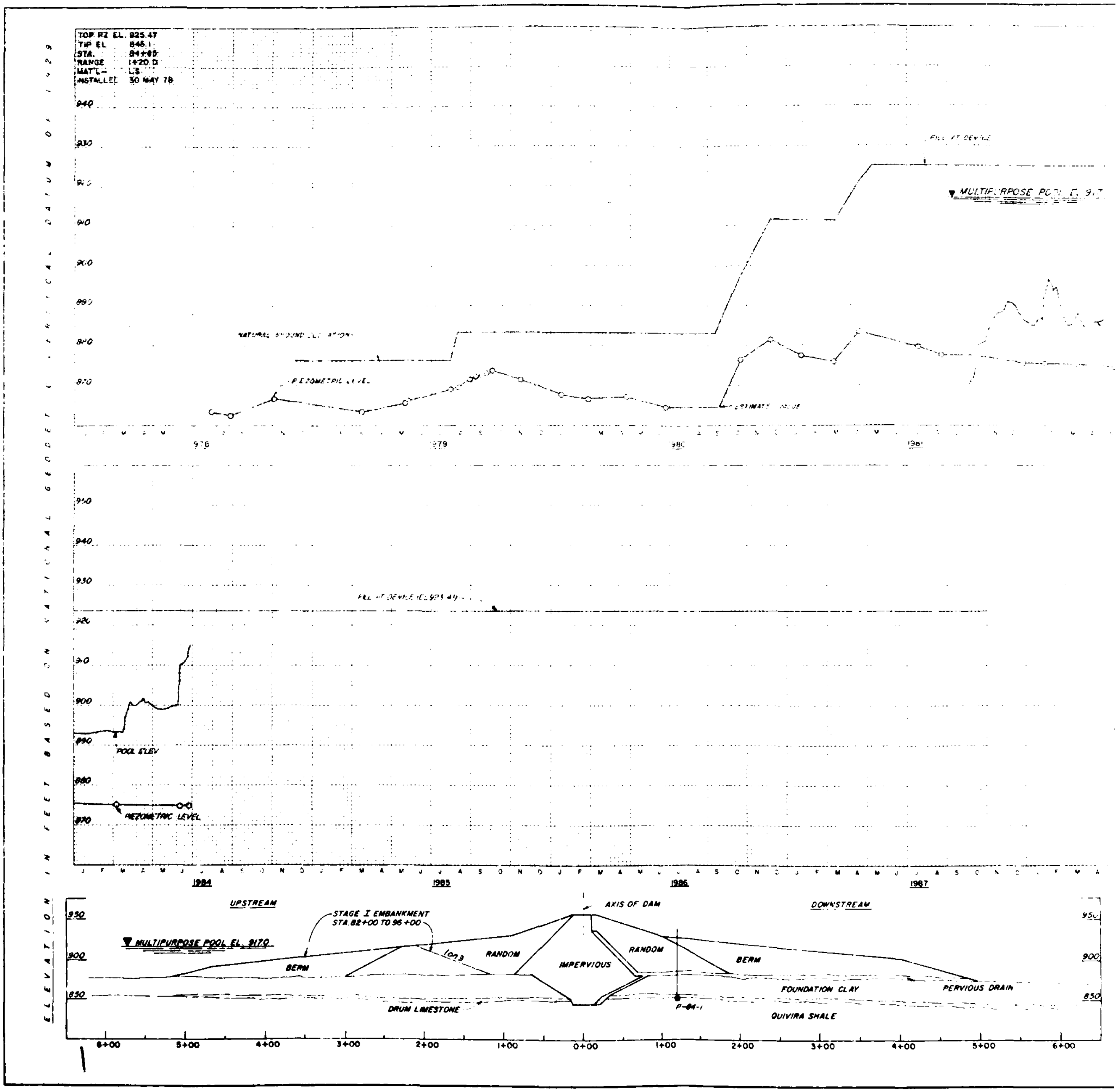
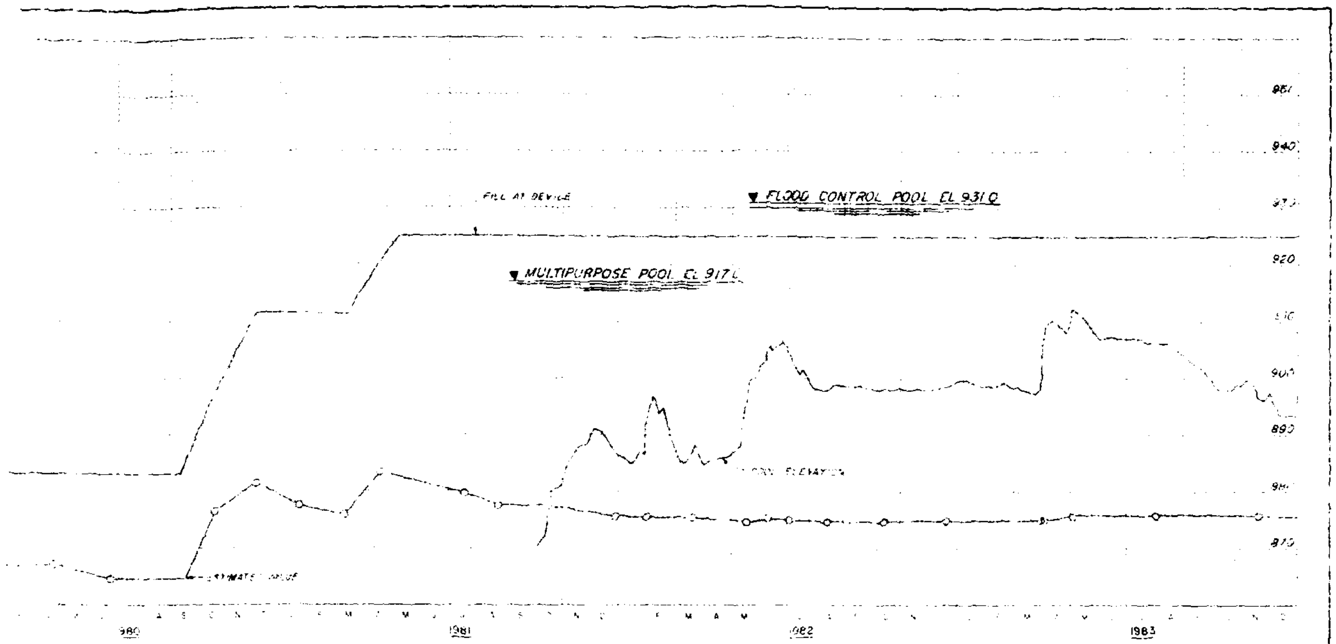
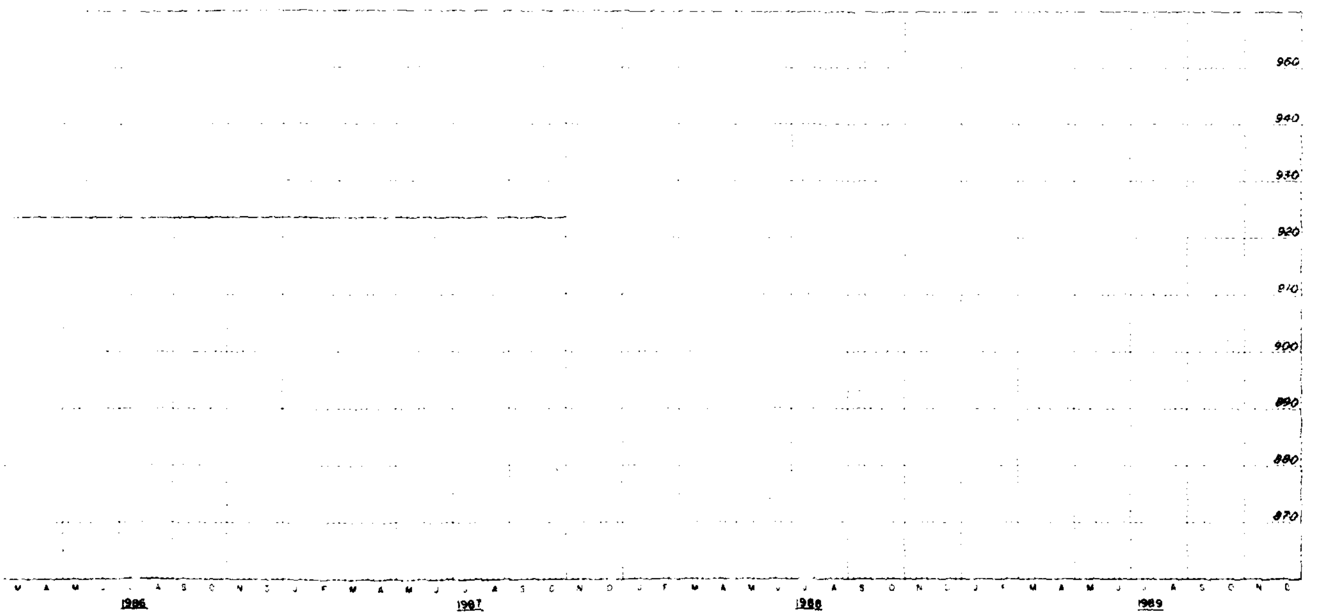
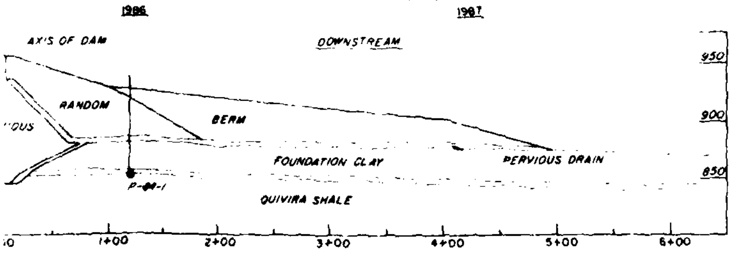
KANSAS CITY DISTRICT
FILE NO. 0-15-936
JANUARY 1983

PLATE NO 207


TOP PZ EL. 925.47
TIP EL 845.1
STA. 84+85
RANGE 1+20 D
MAT'L- LS
INSTALLED 30 MAY 78
NATURAL GROUND ELEVATION
PIEZOMETRIC LEVEL
ESTIMATE
MULTIPURPOSE POOL EL. 917
1979
1981
POOL ELEV
PIEZOMETRIC LEVEL
1984
1985
1986
1987
UPSTREAM
STAGE I EMBANKMENT
STA.82+00 TO 96+00
AXIS OF DAM
DOWNSTREAM
MULTIPURPOSE POOL EL. 917.0
BERM
RANDOM
IMPERVIOUS
RANDOM
BERM
FOUNDATION CLAY
PERVIOUS DRAIN
DRUM LIMESTONE
QUIVIRA SHALE
P-84-1
6+00
5+00
4+00
3+00
2+00
1+00
0+00
1+00
2+00
3+00
4+00
5+00
6+00
ELEVATION IN FEET BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929







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OPEN TUBE PIEZOMETER
P-84-1

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KANSAS CITY DISTRICT

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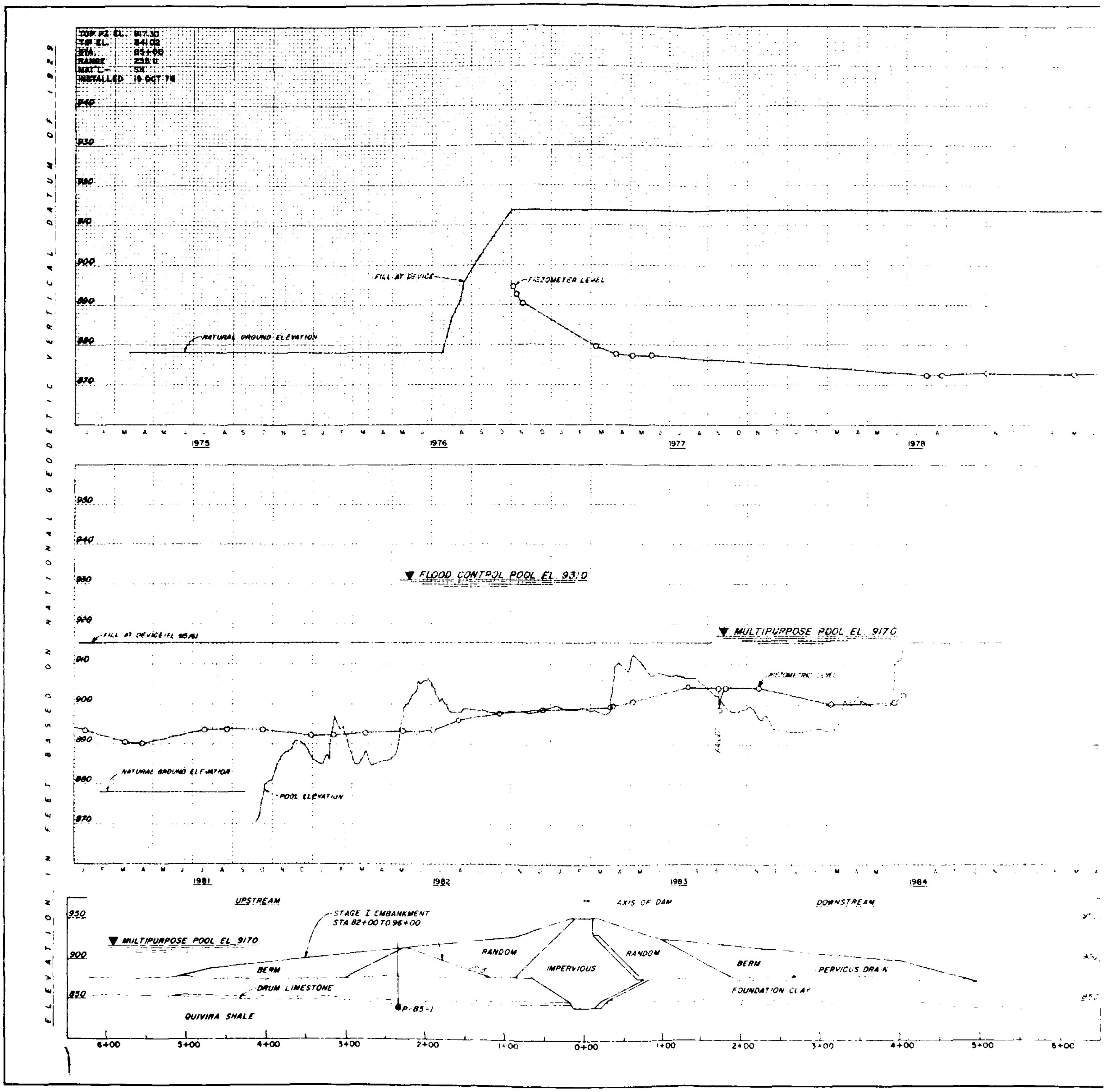
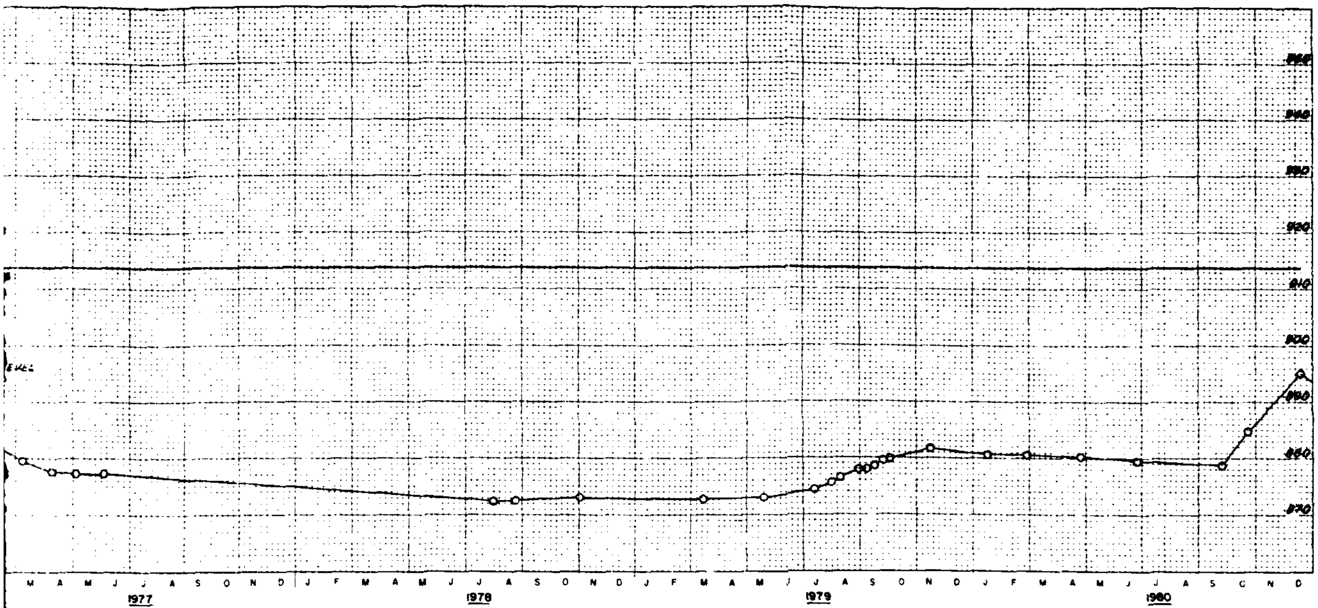
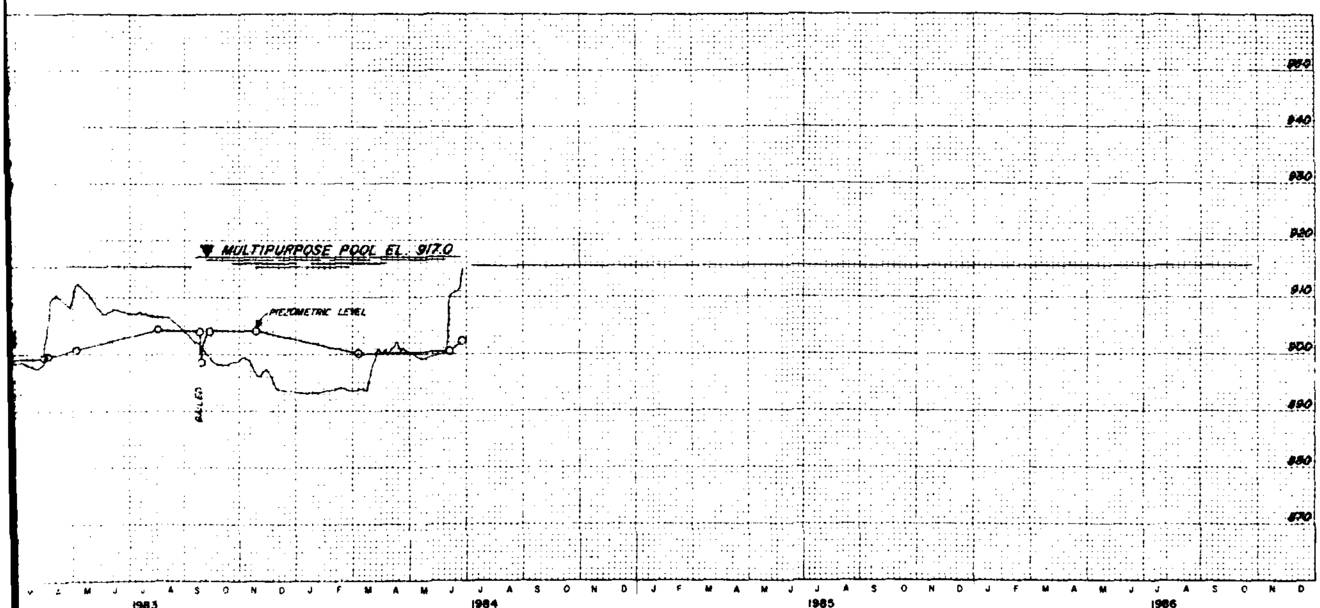
FILE NO O-15-937
JANUARY 1983

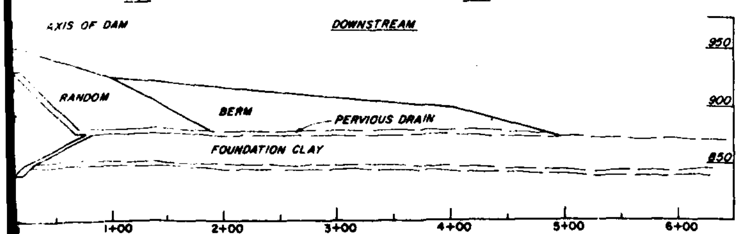
PLATE NO 208



ELEVATION IN FEET BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929
TOP PZ EL.
STA. 85+00
RANGE
MAT'L
INSTALLED
FILL AT DEVICE
PIEZOMETER LEVEL
NATURAL GROUND ELEVATION
1975
1976
1977
1978
FLOOD CONTROL POOL EL. 931.0
MULTIPURPOSE POOL EL. 917.0
FILL AT DEVICE
PIEZOMETRIC LEVEL
NATURAL GROUND ELEVATION
POOL ELEVATION
1981
1982
1983
1984
UPSTREAM
AXIS OF DAM
DOWNSTREAM
STAGE I EMBANKMENT
STA 82+00 TO 96+00
MULTIPURPOSE POOL EL. 917.0
RANDOM
IMPERVIOUS
RANDOM
BERM
BERM
PERVIOUS DRAIN
DRUM LIMESTONE
FOUNDATION CLAY
QUIVIRA SHALE
P-85-1
6+00
5+00
4+00
3+00
2+00
1+00
0+00
1+00
2+00
3+00
4+00
5+00
6+00







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EMBANKMENT CRITERIA REPORT

OPEN TUBE PIEZOMETER
P-85-1

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KANSAS CITY DISTRICT

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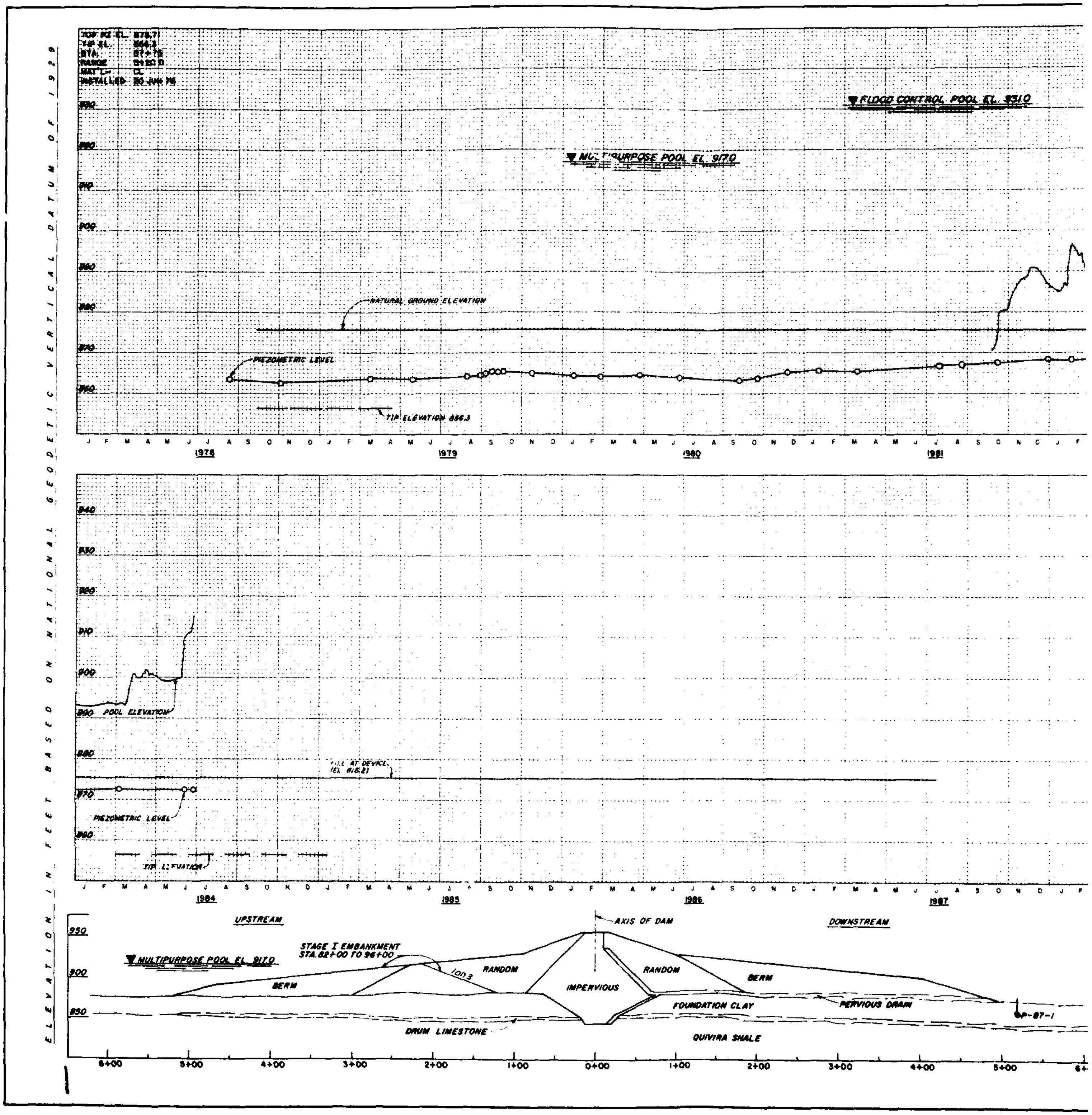
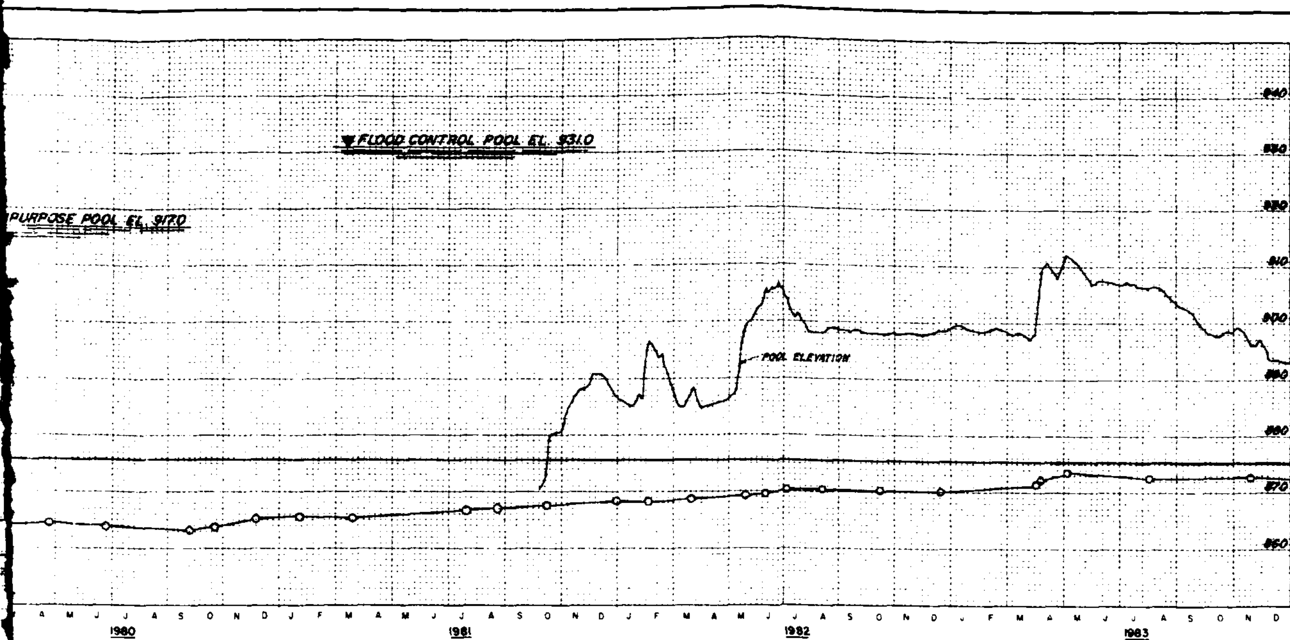
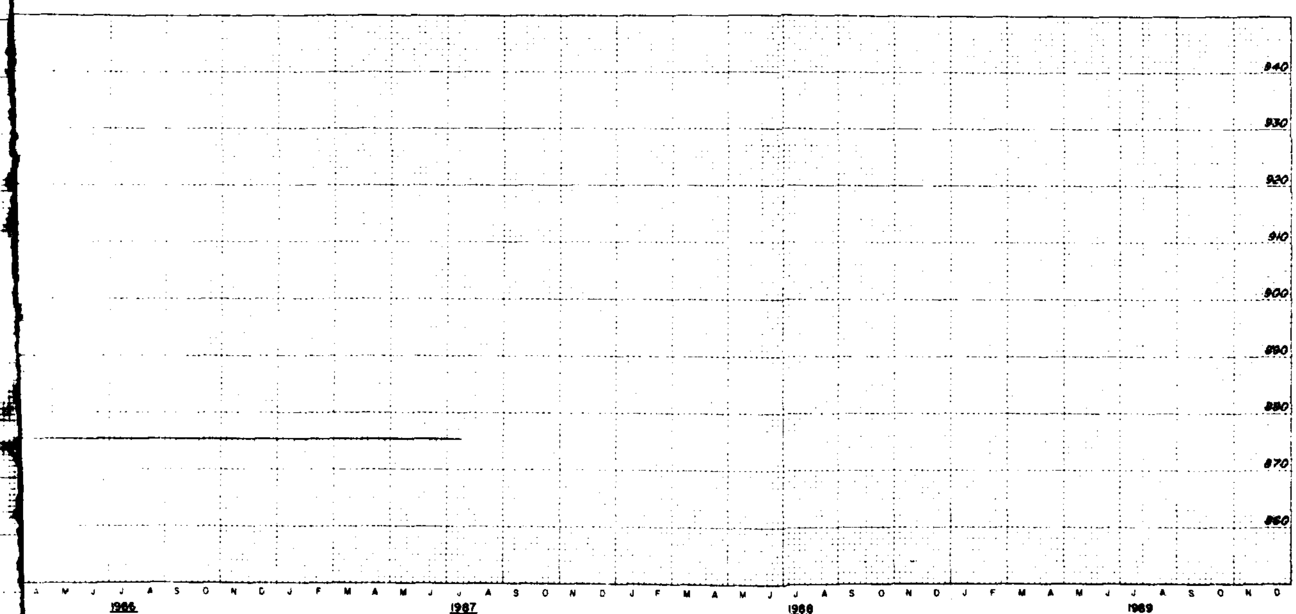
FILE NO. 0-15-938
JANUARY 1983

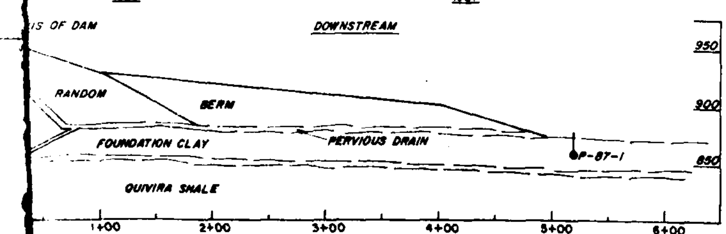
PLATE NO. 209



FLOOD CONTROL POOL EL. 931.0
MULTIPURPOSE POOL EL. 917.0
NATURAL GROUND ELEVATION
PIEZOMETRIC LEVEL
TIP ELEVATION 856.3
1976
1979
1980
1981
POOL ELEVATION
PIEZOMETRIC LEVEL
TIP ELEVATION
1984
1985
1986
1987
ELEVATION IN FEET BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929
UPSTREAM
AXIS OF DAM
DOWNSTREAM
STAGE I EMBANKMENT
STA. 82+00 TO 96+00
MULTIPURPOSE POOL EL. 917.0
RANDOM
BERM
IMPERVIOUS
FOUNDATION CLAY
PERVIOUS DRAIN
DRUM LIMESTONE
QUIVIRA SHALE
P-87-1







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OPEN TUBE PIEZOMETER P-87-1

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FILE NO. 0-15-940
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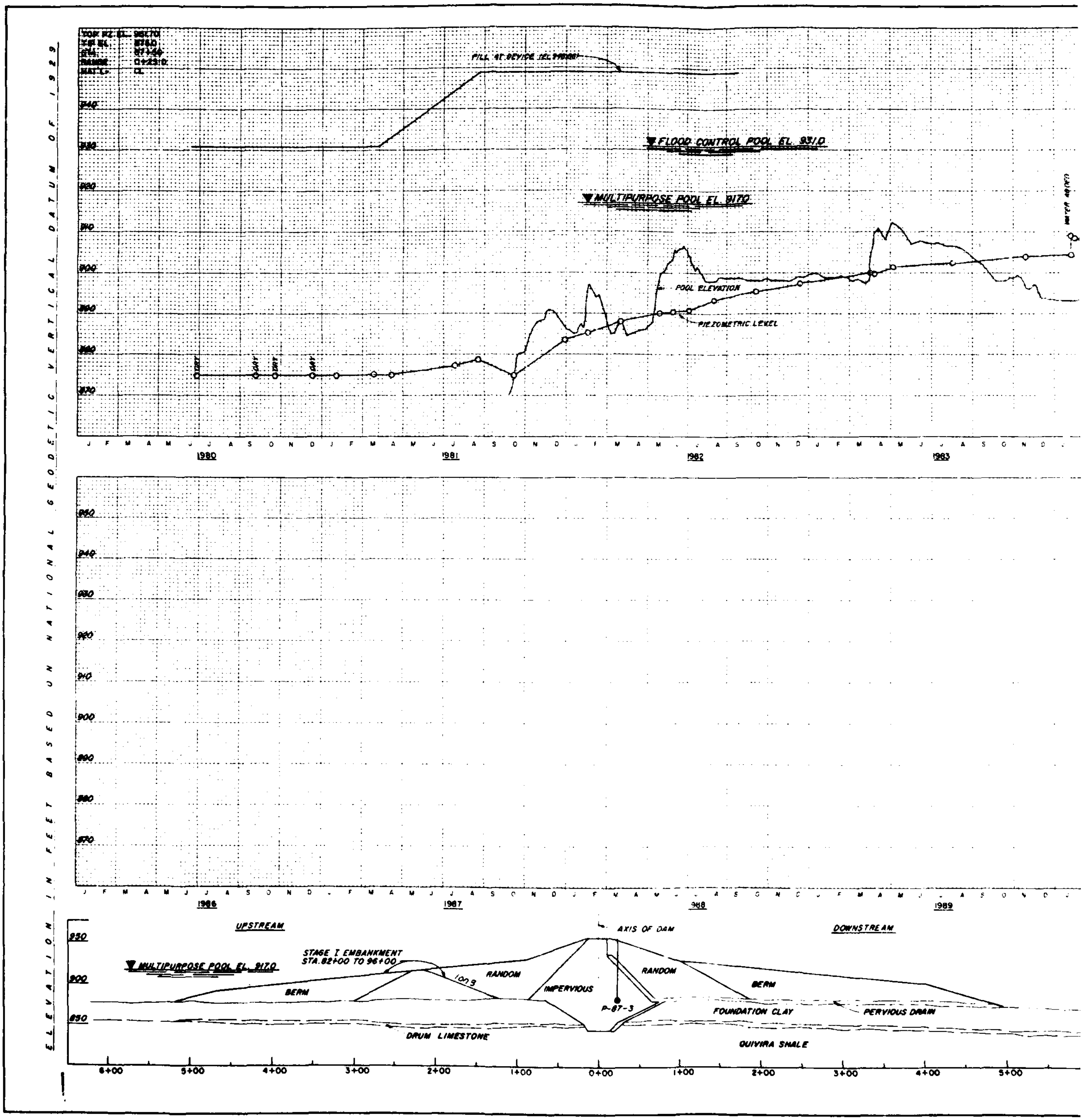
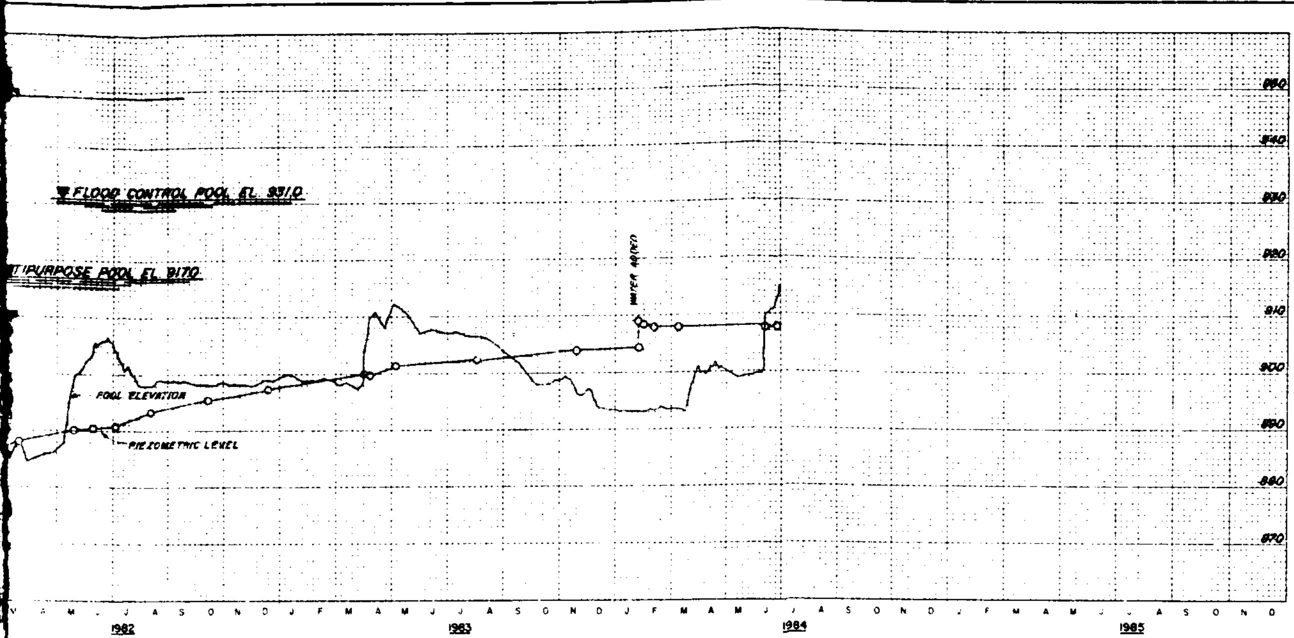
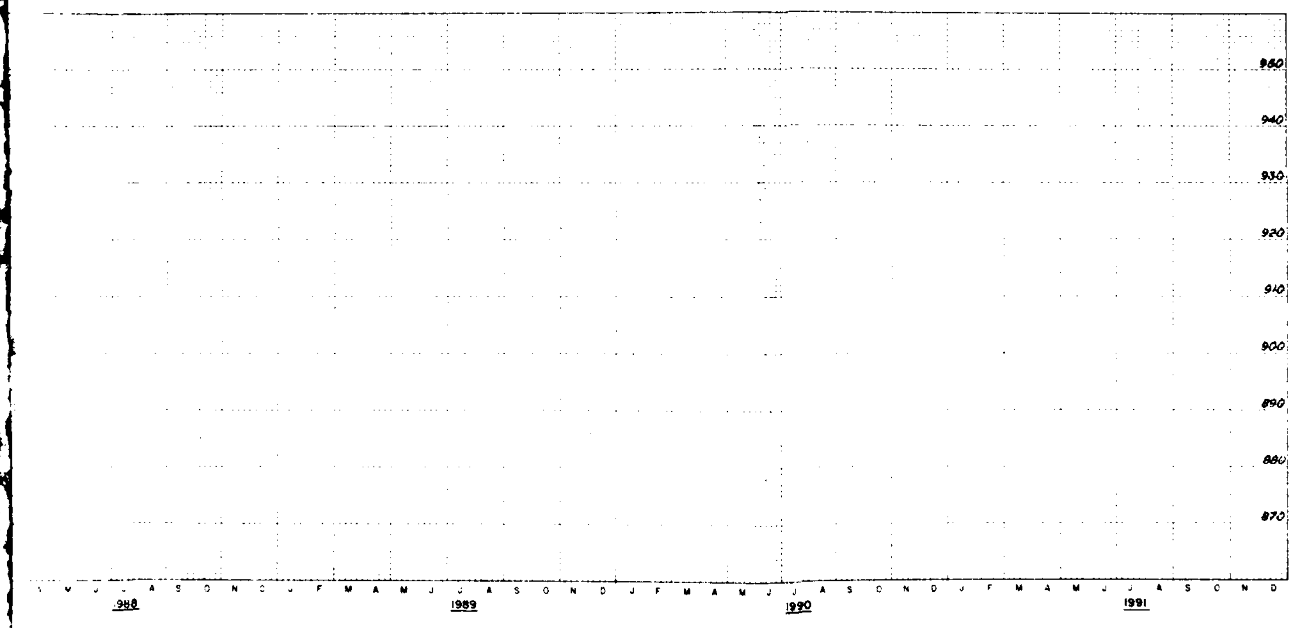
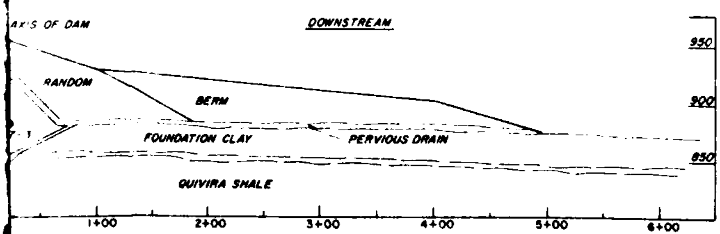


ELEVATION IN FEET BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929
FILL AT DEVICE
FLOOD CONTROL POOL EL. 931.0
MULTIPURPOSE POOL EL. 917.0
POOL ELEVATION
PIEZOMETRIC LEVEL
DRY
DRY
DRY
DRY
940
930
920
910
900
890
880
870
J F M A M J J A S O N D
1980
1981
1982
1983
950
940
930
920
910
900
890
880
870
1986
1987
1988
1989
UPSTREAM
AXIS OF DAM
DOWNSTREAM
STAGE I EMBANKMENT
STA.82+00 TO 96+00
MULTIPURPOSE POOL EL. 917.0
RANDOM
BERM
IMPERVIOUS
RANDOM
BERM
P-87-3
FOUNDATION CLAY
PERVIOUS DRAIN
DRUM LIMESTONE
QUIVIRA SHALE
950
900
850
6+00
5+00
4+00
3+00
2+00
1+00
0+00
1+00
2+00
3+00
4+00
5+00







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OPEN TUBE PIEZOMETER
P-87-3

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KANSAS CITY DISTRICT
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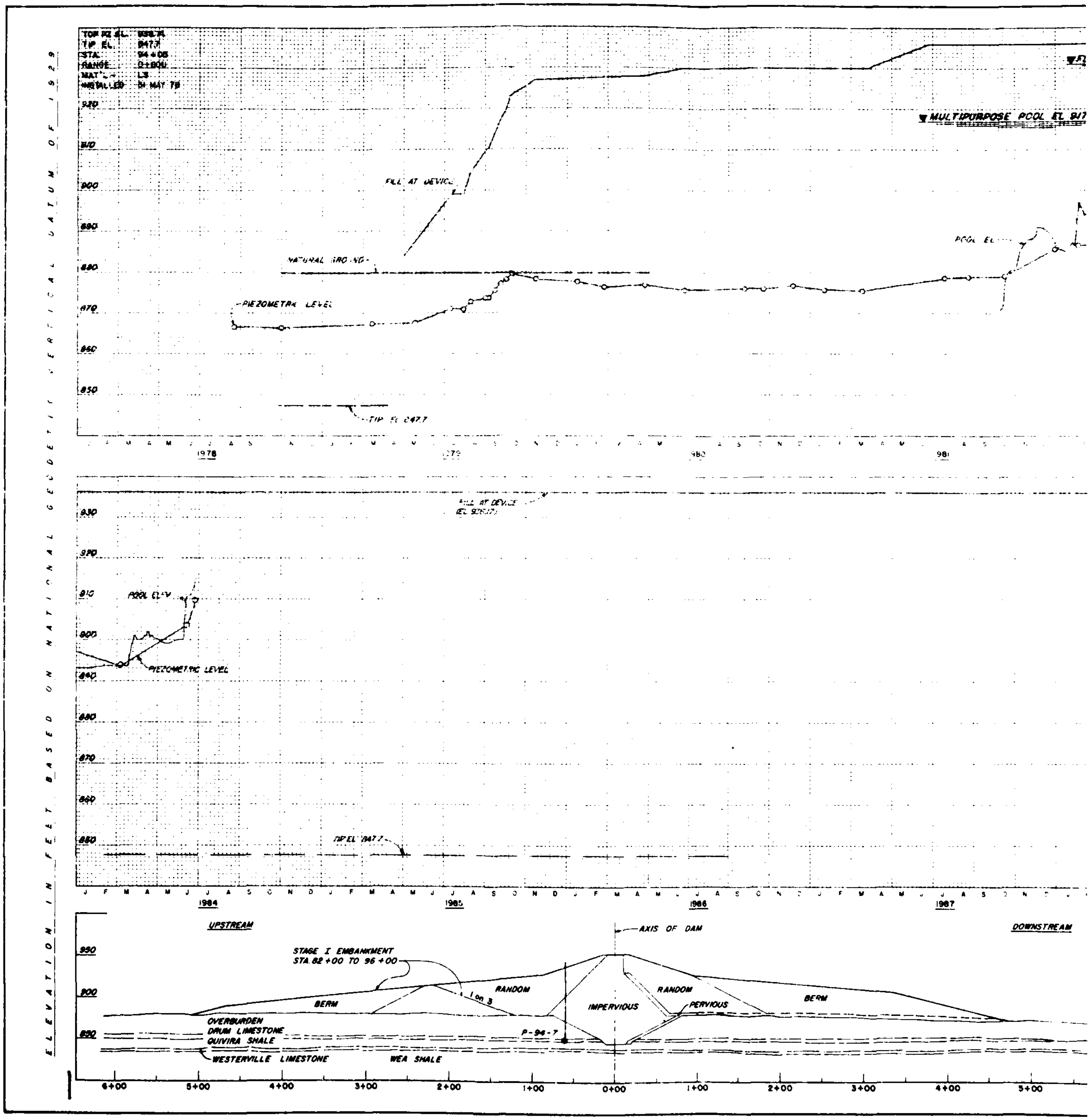
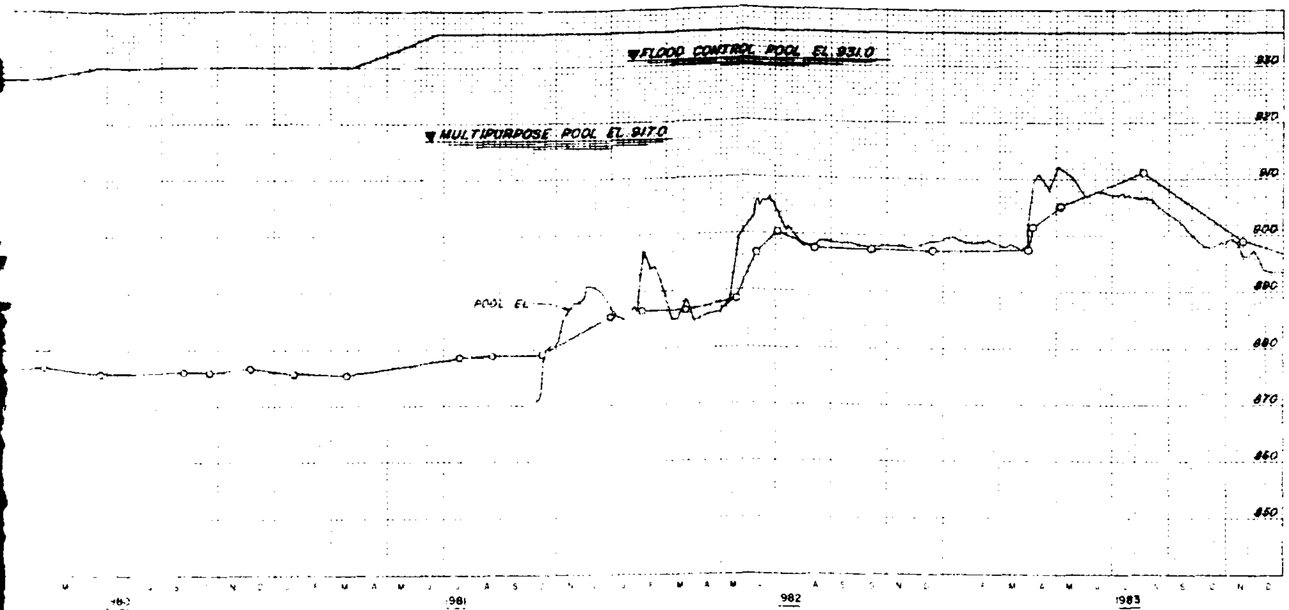
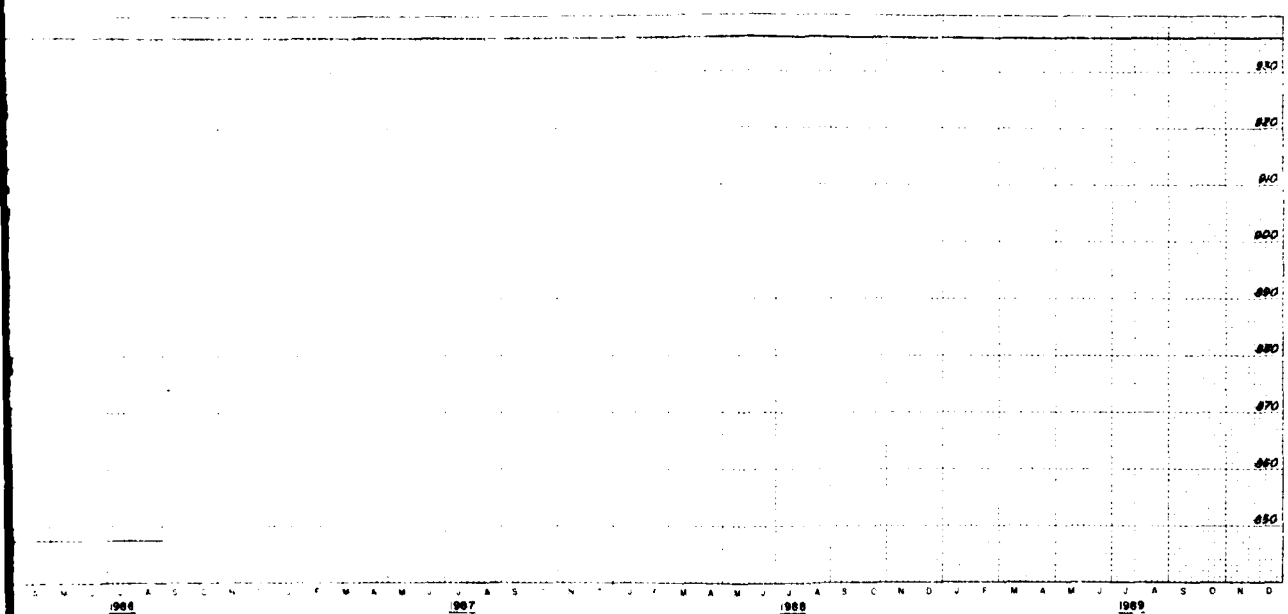
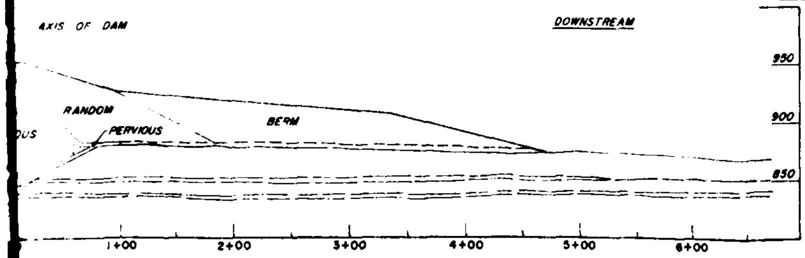
JANUARY 1983



TOP PZ EL.
TIP EL.
STA.
RANGE
INSTALLED
MULTIPURPOSE POOL EL 917
FILL AT DEVICE
NATURAL GROUND
POOL EL
PIEZOMETRIC LEVEL
TIP EL 847.7
1978
1981
FILL AT DEVICE
POOL ELEV
PIEZOMETRIC LEVEL
TIP EL 847.7
1984
1985
1986
1987
ELEVATION IN FEET BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929
UPSTREAM
AXIS OF DAM
DOWNSTREAM
STAGE I EMBANKMENT
STA. 82+00 TO 96+00
RANDOM
BERM
1 on 3
IMPERVIOUS
PERVIOUS
OVERBURDEN
DRUM LIMESTONE
QUIVIRA SHALE
P-94-7
WESTERVILLE LIMESTONE
WEA SHALE
6+00
5+00
4+00
3+00
2+00
1+00
0+00
1+00
2+00
3+00
4+00
5+00







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BIG BULL CREEK, KANSAS

HILLSDALE LAKE

EMBANKMENT CRITERIA REPORT

OPEN TUBE PIEZOMETER
P-94-7

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KANSAS CITY DISTRICT
FILE NO. 0-15-951
JANUARY 1983

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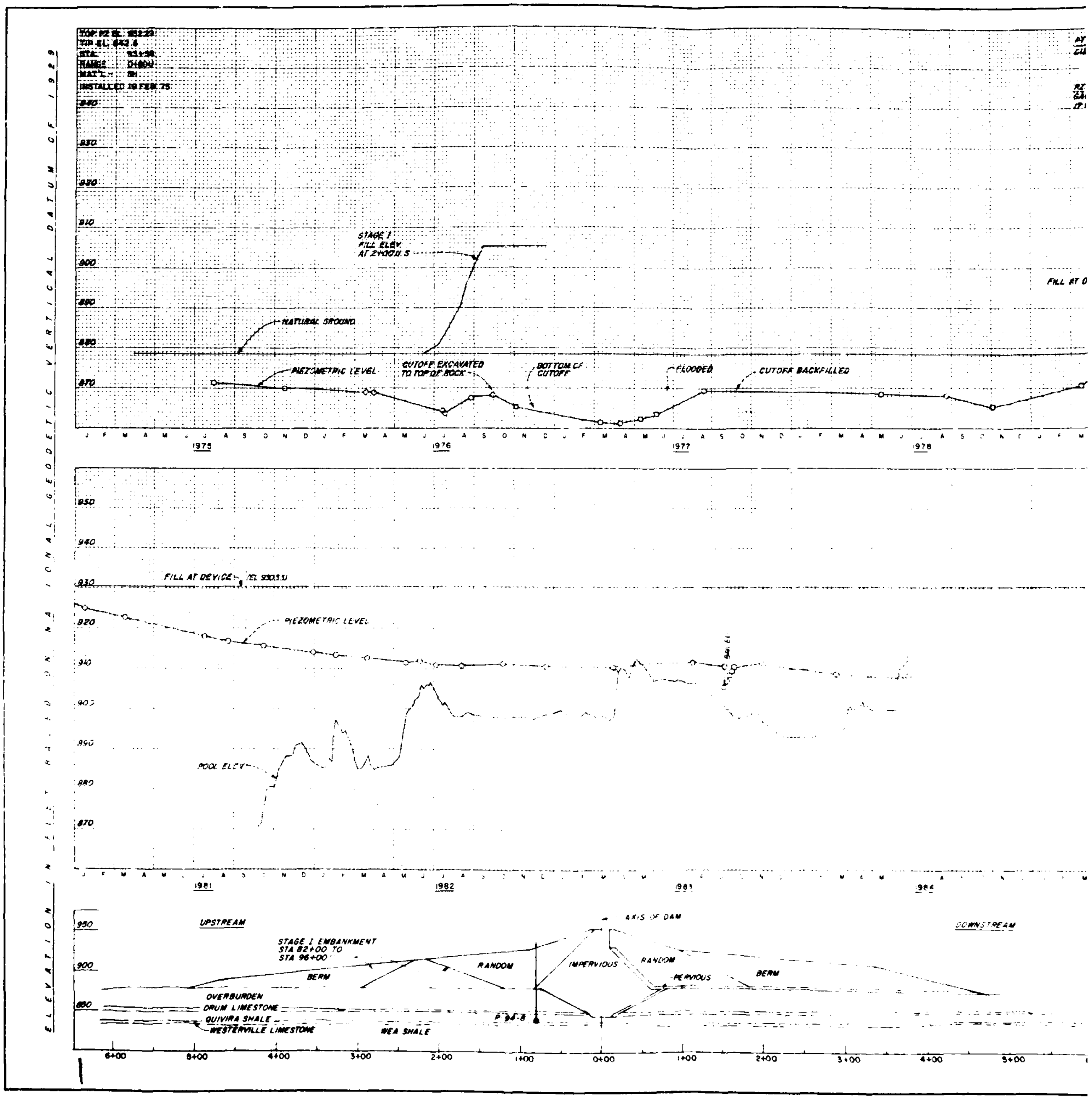
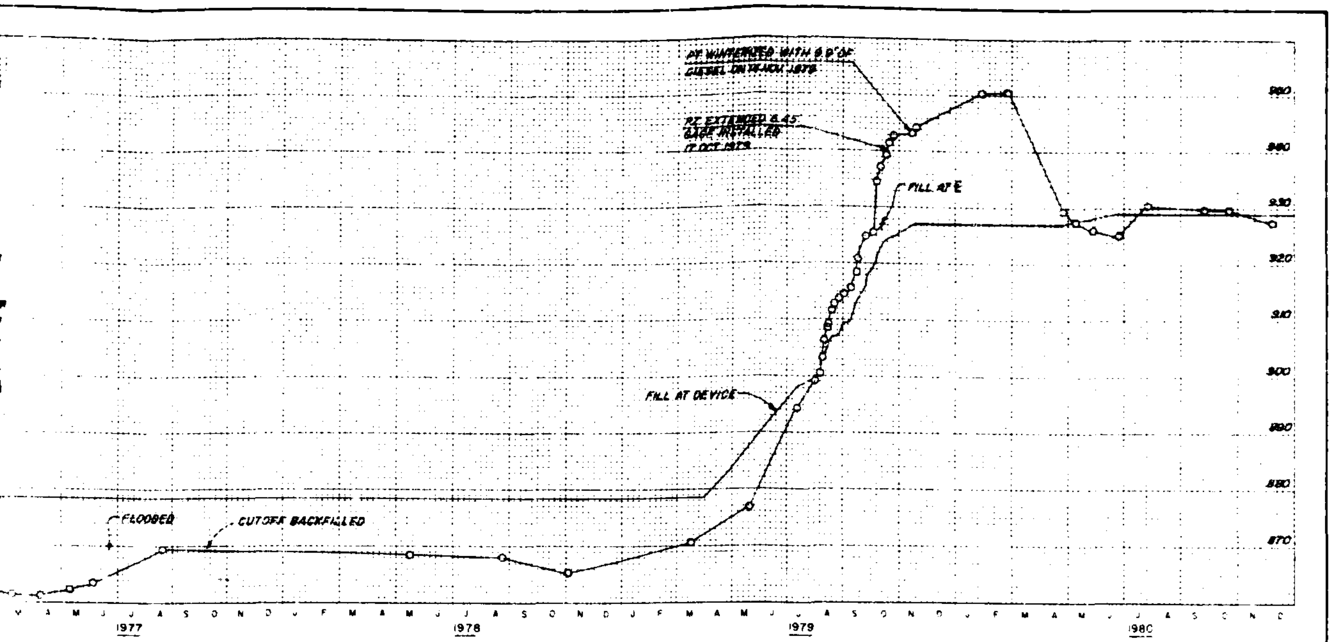
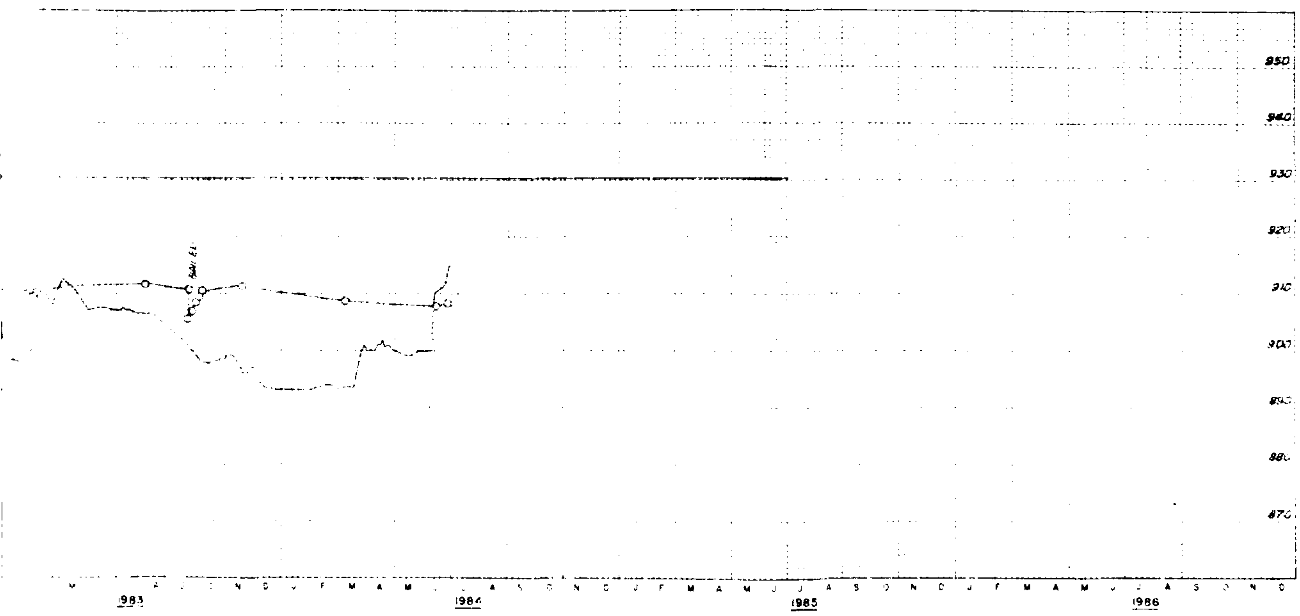
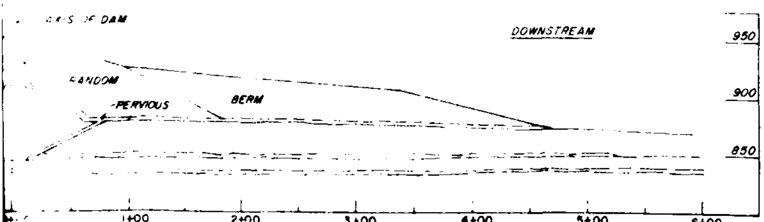


ELEVATION IN FEET REFERRED TO NATIONAL GEODETIC VERTICAL DATUM OF 1929
STAGE I FILL ELEV. AT 2+00 U.S.
NATURAL GROUND
PIEZOMETRIC LEVEL
CUTOFF EXCAVATED TO TOP OF ROCK
BOTTOM OF CUTOFF
FLOODED
CUTOFF BACKFILLED
FILL AT D
1975
1976
1977
1978
FILL AT DEVICE
PIEZOMETRIC LEVEL
POOL ELEV
1981
1982
1983
1984
UPSTREAM
AXIS OF DAM
DOWNSTREAM
STAGE I EMBANKMENT STA 82+00 TO STA 96+00
RANDOM
IMPERVIOUS
RANDOM
BERM
PERVIOUS
BERM
OVERBURDEN
DRUM LIMESTONE
QUIVIRA SHALE
WESTERVILLE LIMESTONE
WEA SHALE







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OPEN TUBE PIEZOMETER
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FILE NO. 0-15-952
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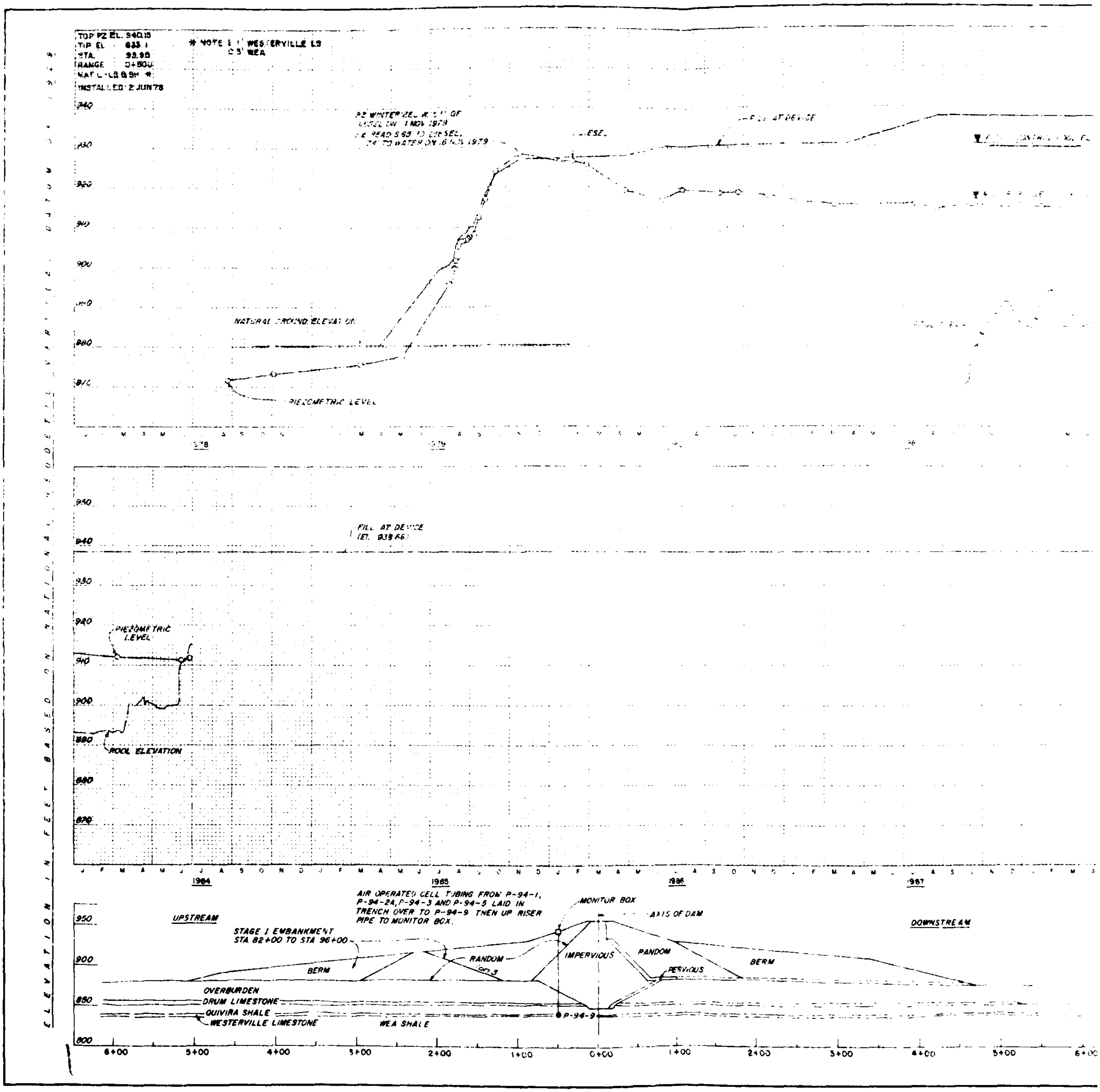
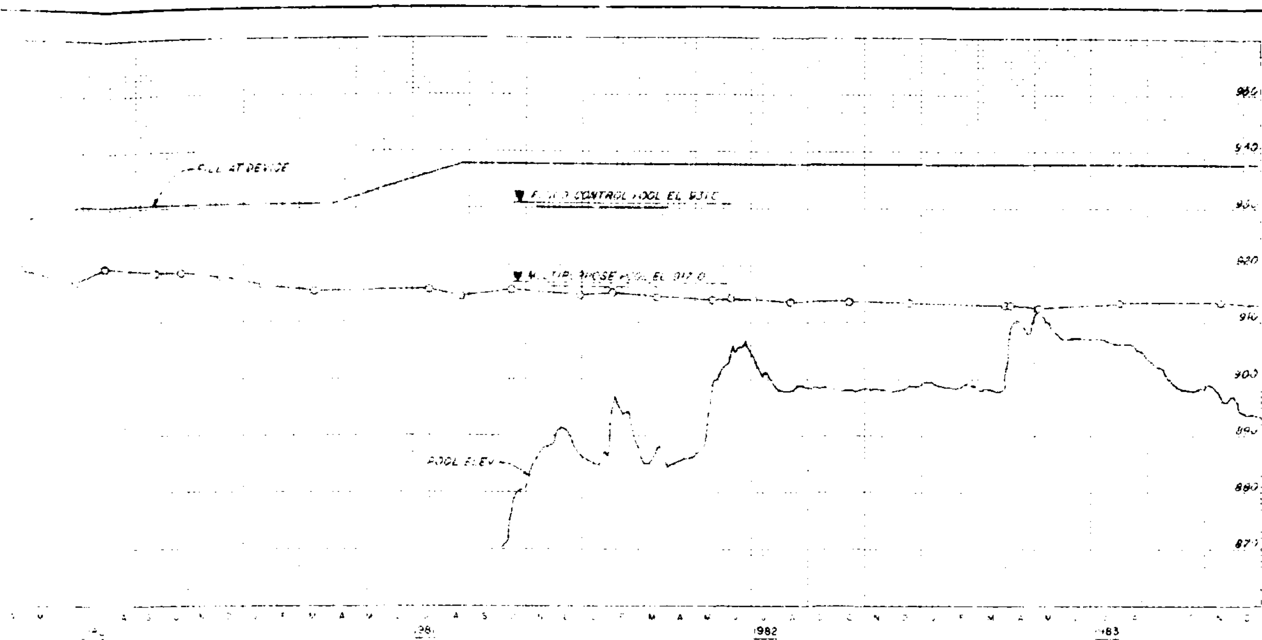
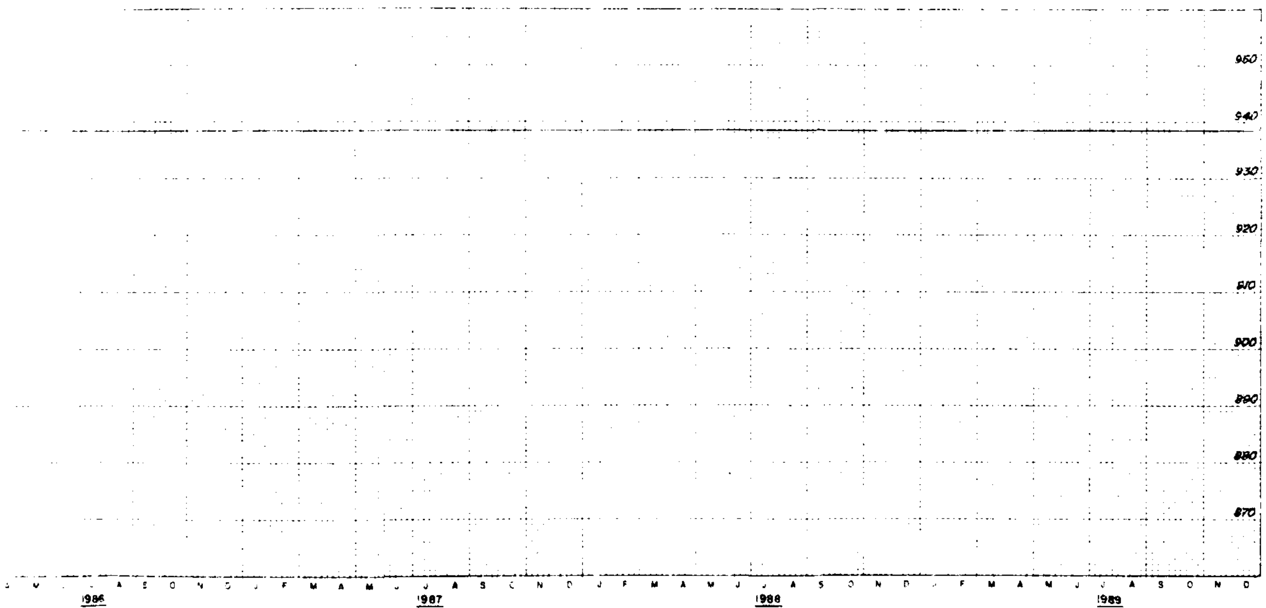
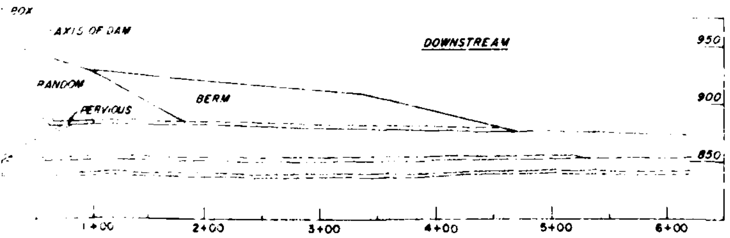
PLATE NO 223



TOP PZ EL. 940.15
STA 95.90
INSTALLED 2 JUN 78
NATURAL GROUND ELEVATION
PIEZOMETRIC LEVEL
1978
1979
FILL AT DEVICE (EL. 939.66)
PIEZOMETRIC LEVEL
POOL ELEVATION
1984
1985
1986
1987
AIR OPERATED CELL TUBING FROM P-94-1, P-94-2A, P-94-3 AND P-94-5 LAID IN TRENCH OVER TO P-94-9 THEN UP RISER PIPE TO MONITOR BOX.
MONITOR BOX
AXIS OF DAM
UPSTREAM
DOWNSTREAM
STAGE I EMBANKMENT STA 82+00 TO STA 96+00
RANDOM
IMPERVIOUS
RANDOM
PERVIOUS
BERM
BERM
OVERBURDEN
DRUM LIMESTONE
QUIVIRA SHALE
WESTERVILLE LIMESTONE
WEA SHALE
P-94-9
ELEVATION IN FEET BASED ON NATIONAL GEODETIC VERTICAL DATUM







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EMBANKMENT CRITERIA REPORT

OPEN TUBE PIEZOMETER P-94-9

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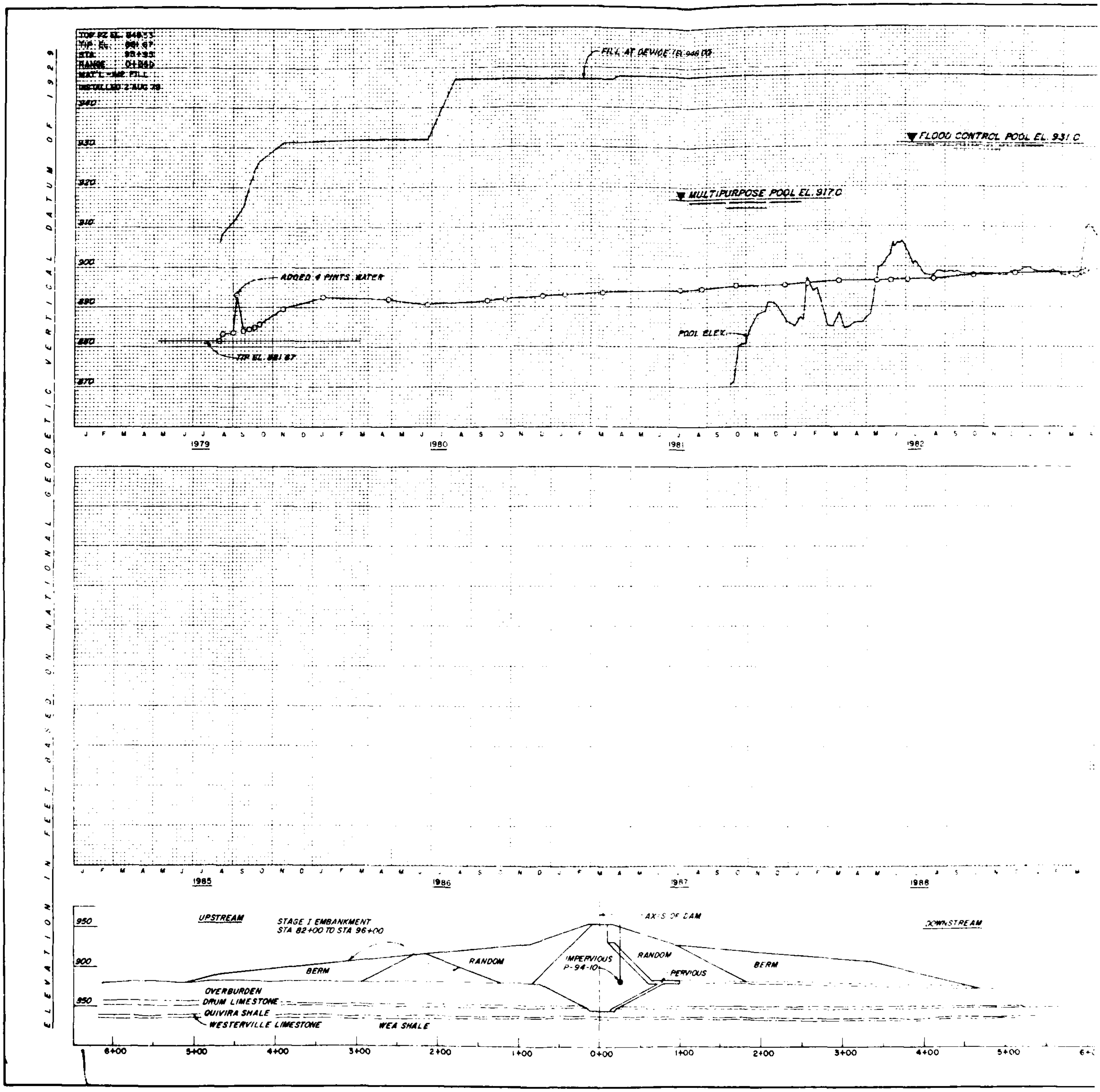
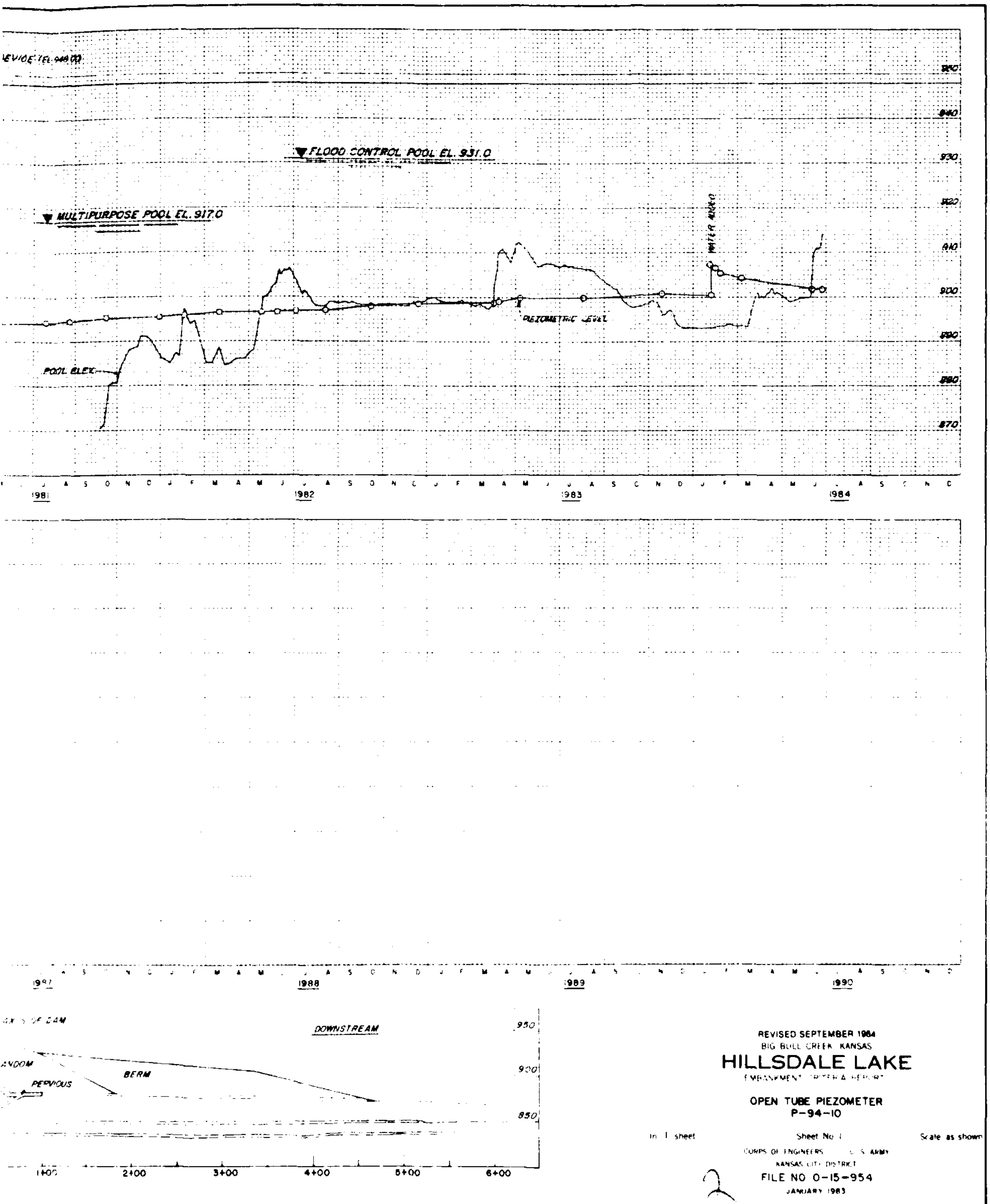
KANSAS CITY DISTRICT

FILE NO. 0-15-953

JANUARY 1983


ELEVATION IN FEET BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929
RANGE
FILL AT DEVICE
FLOOD CONTROL POOL EL. 931.C
MULTIPURPOSE POOL EL. 917.C
ADDED 4 PINTS WATER
POOL ELEV.
TIP EL.
940
930
920
910
900
890
880
870
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N
1979
1980
1981
1982
1985
1986
1987
1988
950
900
850
UPSTREAM
STAGE I EMBANKMENT
STA 82+00 TO STA 96+00
AXIS OF DAM
DOWNSTREAM
BERM
RANDOM
IMPERVIOUS
P-94-10
RANDOM
PERVIOUS
BERM
OVERBURDEN
DRUM LIMESTONE
QUIVIRA SHALE
WESTERVILLE LIMESTONE
WEA SHALE
6+00
5+00
4+00
3+00
2+00
1+00
0+00
1+00
2+00
3+00
4+00
5+00



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BIG BULL CREEK KANSAS

HILLSDALE LAKE

EMBANKMENT CRITERIA REPORT

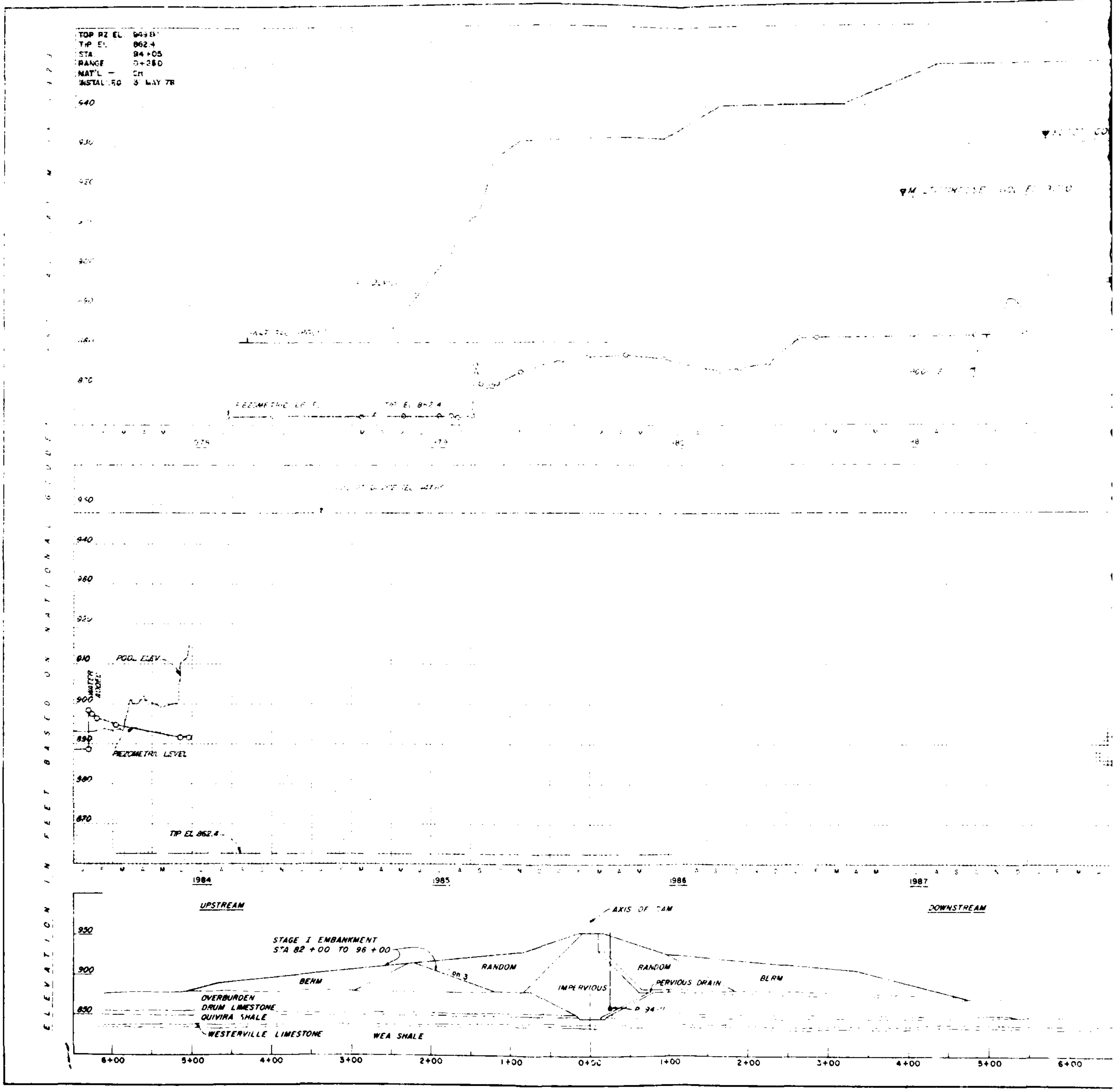
OPEN TUBE PIEZOMETER
P-94-10

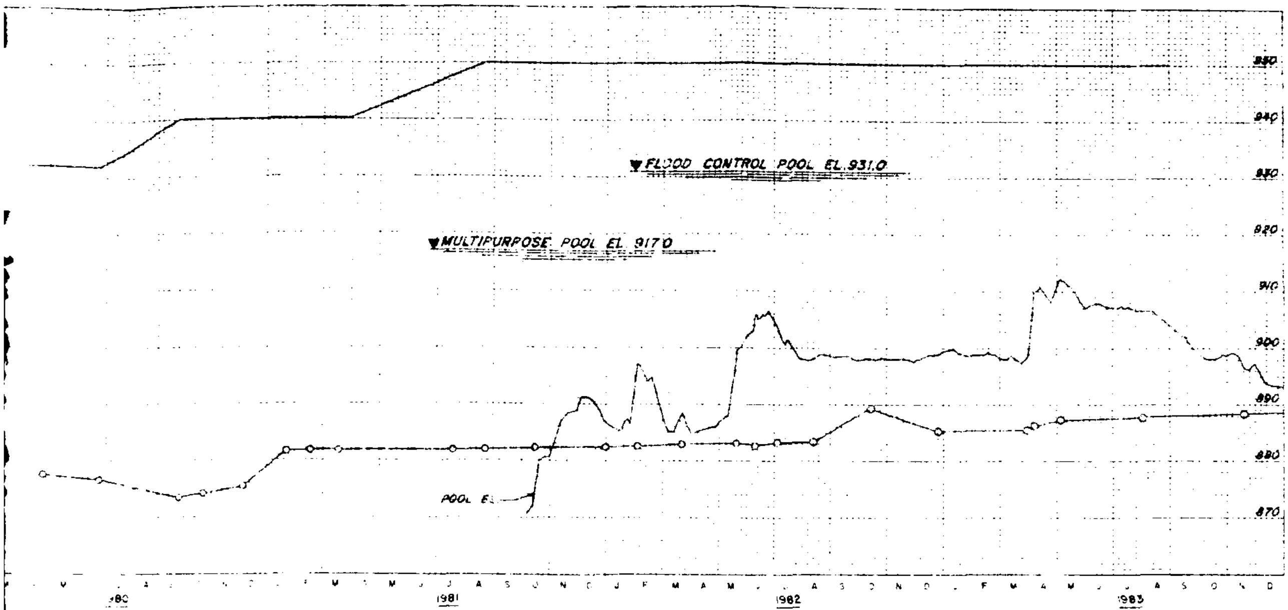
In 1 sheet | Sheet No. 1 | Scale as shown

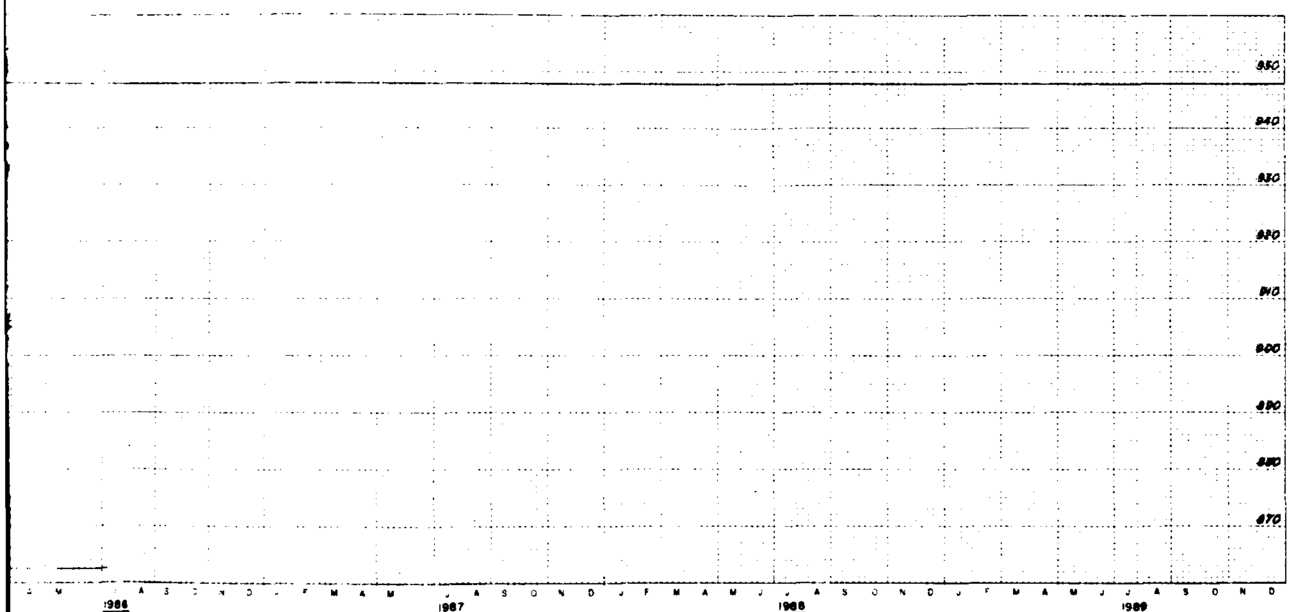
CORPS OF ENGINEERS U. S. ARMY
KANSAS CITY DISTRICT

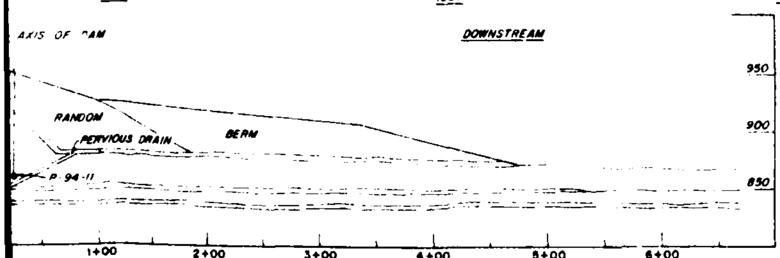
FILE NO. 0-15-954
JANUARY 1983

PLATE NO 225


TOP PZ EL 949.8
TIP EL 862.4
STA 94+05
RANGE 0+35D
MAT'L CH
INSTALLED 3 MAY 78
POOL ELEV
WATER ABOVE
PIEZOMETRIC LEVEL
TIP EL 862.4
1984
1985
1986
1987
UPSTREAM
DOWNSTREAM
AXIS OF DAM
STAGE I EMBANKMENT
STA 82 + 00 TO 96 + 00
RANDOM
BERM
IMPERVIOUS
PERVIOUS DRAIN
OVERBURDEN
DRUM LIMESTONE
QUIVIRA SHALE
WESTERVILLE LIMESTONE
WEA SHALE
ELEVATION IN FEET BASED ON NATIONAL GEODETIC VERTICAL DATUM
6+00
5+00
4+00
3+00
2+00
1+00
0+00







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BIG BULL CREEK, KANSAS

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EMBANKMENT CRITERIA REPORT

OPEN TUBE PIEZOMETER
P-94-11

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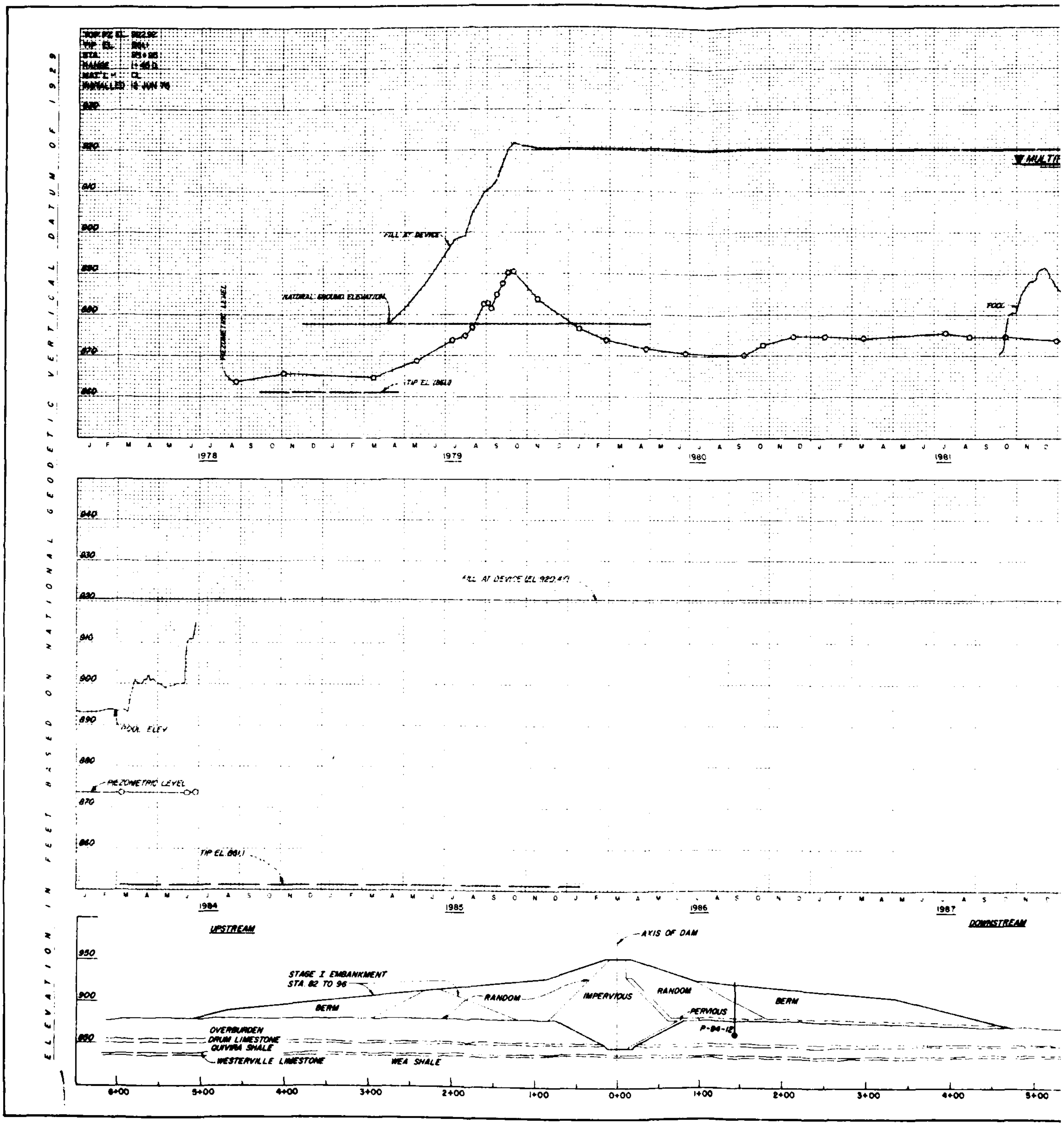
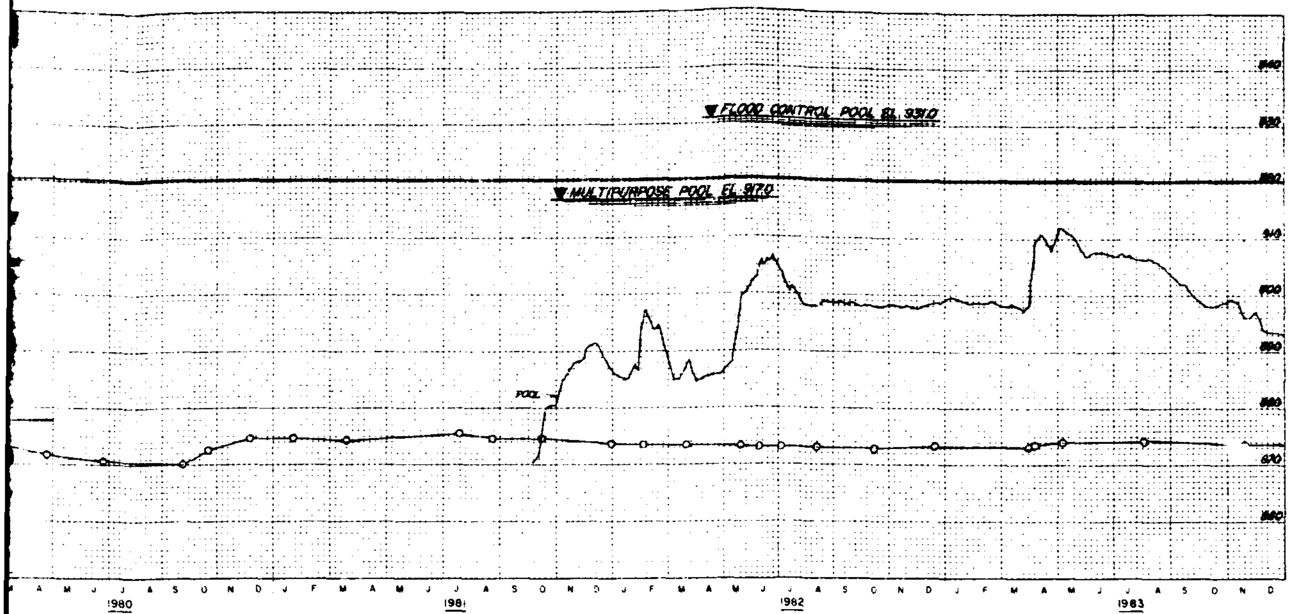
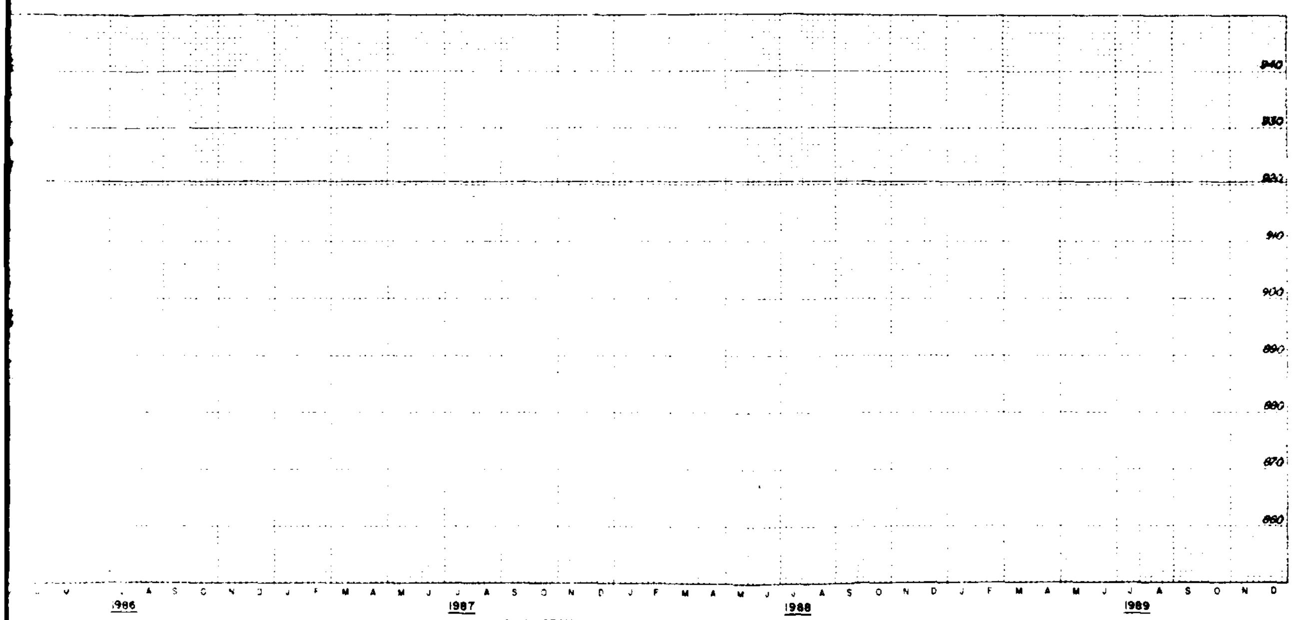
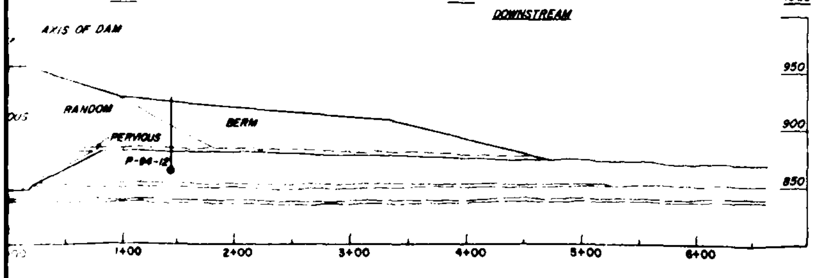
PLATE NO 226


ELEVATION IN FEET BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929
FILL AT DEVICE
NATURAL GROUND ELEVATION
PIEZOMETRIC LEVEL
TIP EL.
POOL
1978
1979
1980
1981
FILL AT DEVICE (EL 920.4?)
POOL ELEV
PIEZOMETRIC LEVEL
TIP EL 861
1984
1985
1986
1987
UPSTREAM
DOWNSTREAM
AXIS OF DAM
STAGE I EMBANKMENT STA. 82 TO 96
RANDOM
IMPERVIOUS
RANDOM
BERM
BERM
PERVIOUS
P-84-12
OVERBURDEN
DRUM LIMESTONE
QUIVIRA SHALE
WESTERVILLE LIMESTONE
WEA SHALE
6+00
5+00
4+00
3+00
2+00
1+00
0+00
1+00
2+00
3+00
4+00
5+00







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EMBANKMENT CRITERIA REPORT

OPEN TUBE PIEZOMETER P-94-12

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CORPS OF ENGINEERS U.S. ARMY
KANSAS CITY DISTRICT
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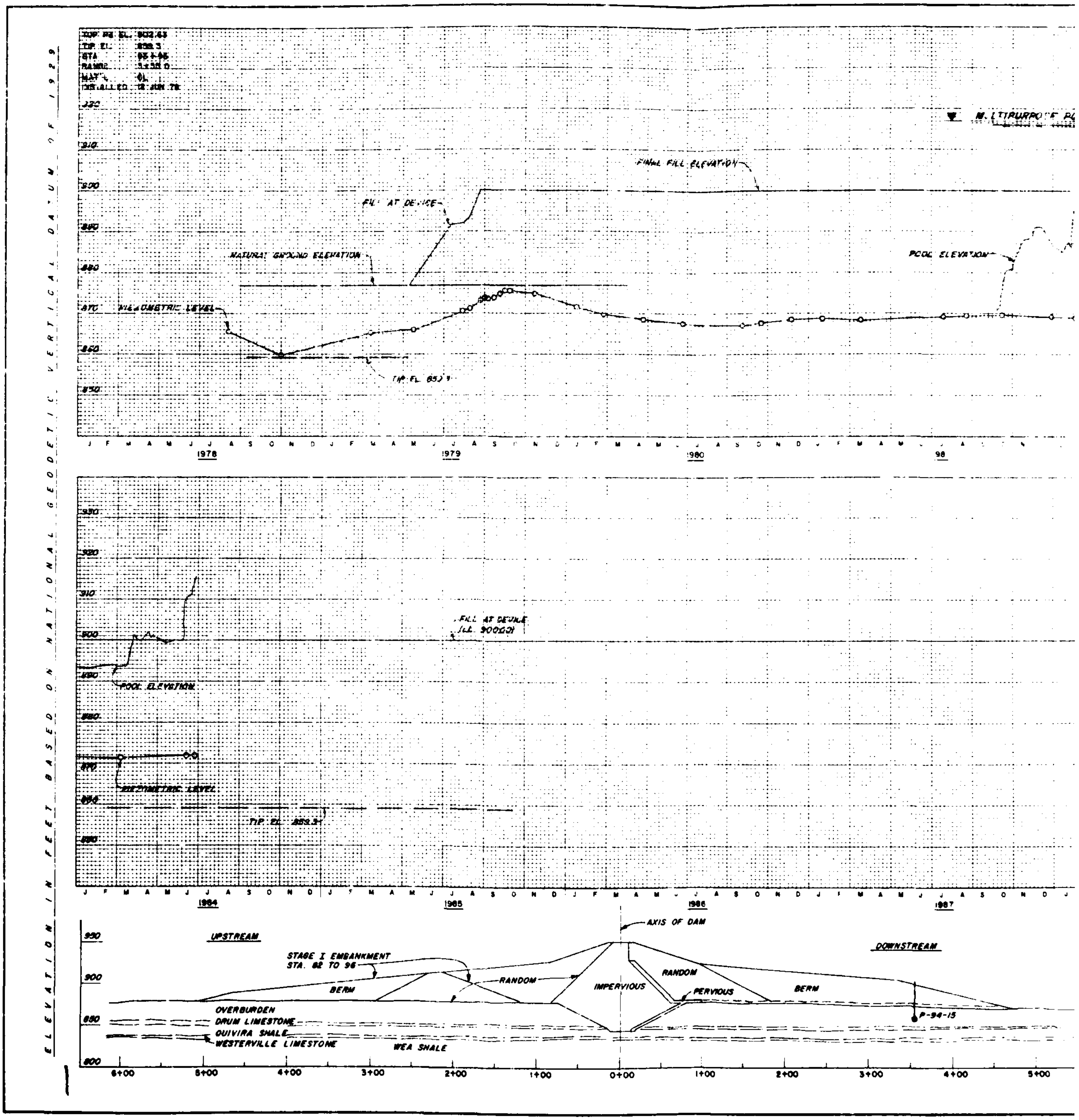
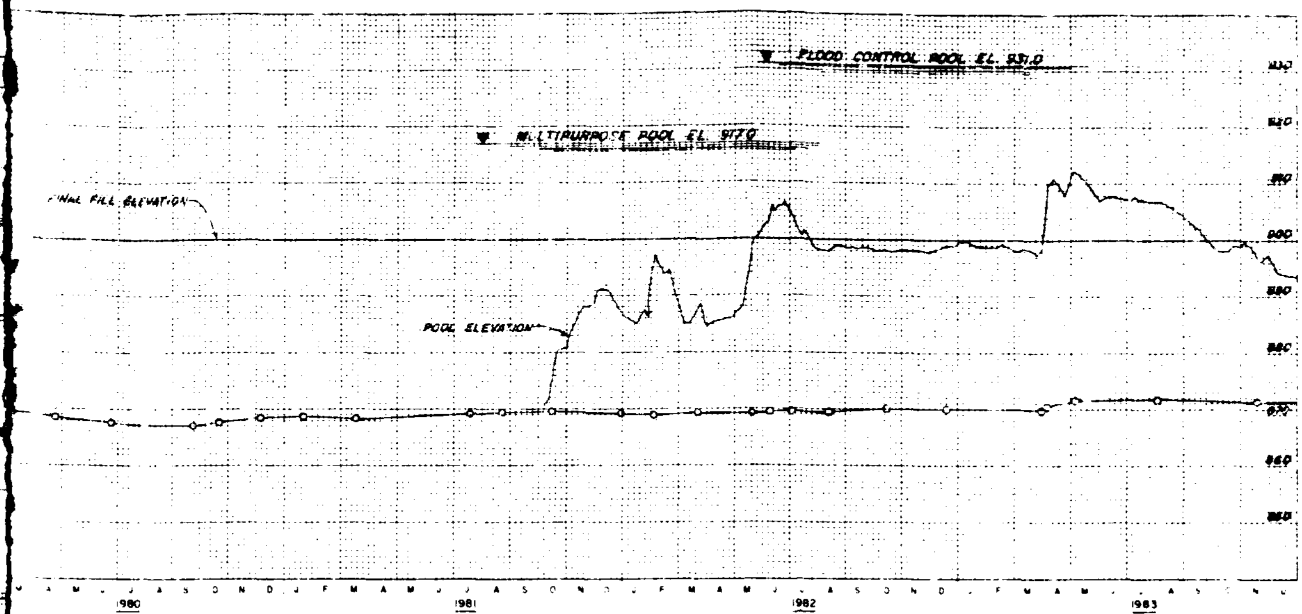
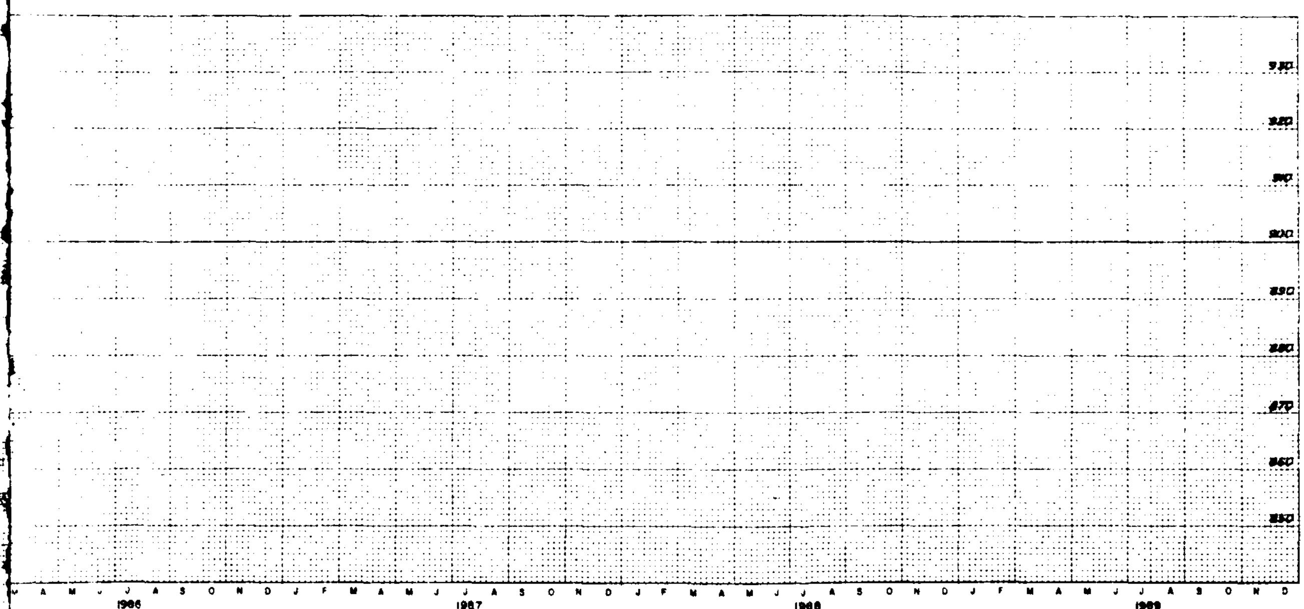
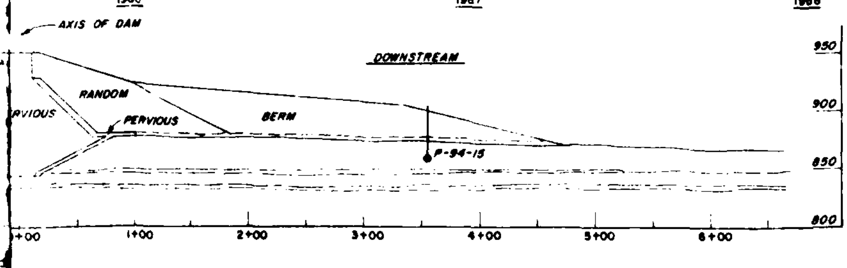
PLATE NO 227



TOP PR EL. 902.63
TIP EL 859.3
FINAL FILL ELEVATION
FILL AT DEVICE
NATURAL GROUND ELEVATION
PIEZOMETRIC LEVEL
POOL ELEVATION
1978
1979
1980
FILL AT DEVICE
POOL ELEVATION
PIEZOMETRIC LEVEL
1984
1985
1986
1987
AXIS OF DAM
UPSTREAM
DOWNSTREAM
STAGE I EMBANKMENT
STA. 82 TO 96
BERM
RANDOM
IMPERVIOUS
PERVIOUS
OVERBURDEN
DRUM LIMESTONE
QUIVIRA SHALE
WESTERVILLE LIMESTONE
WEA SHALE
P-94-15







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OPEN TUBE PIEZOMETER
P-94-15

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KANSAS CITY DISTRICT
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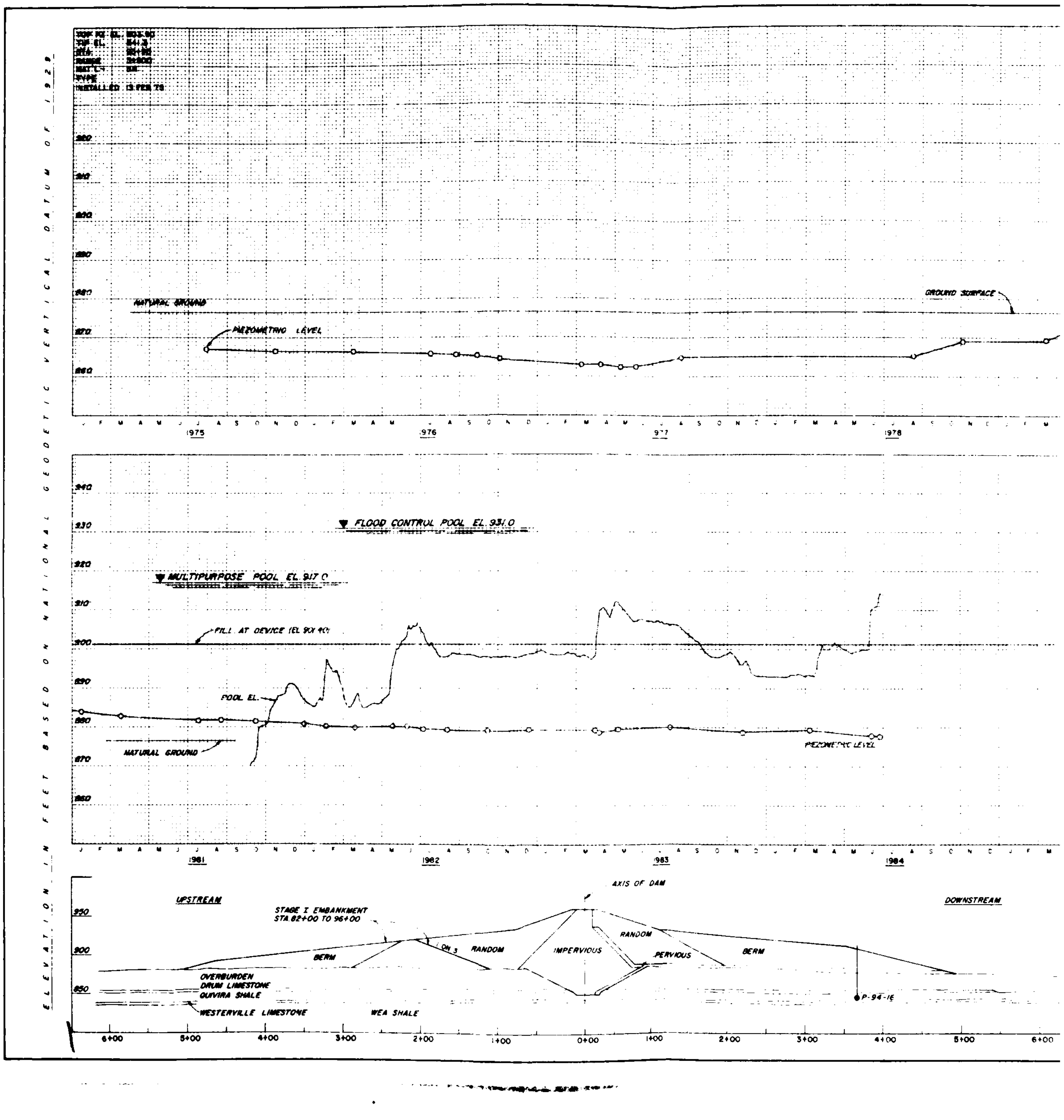
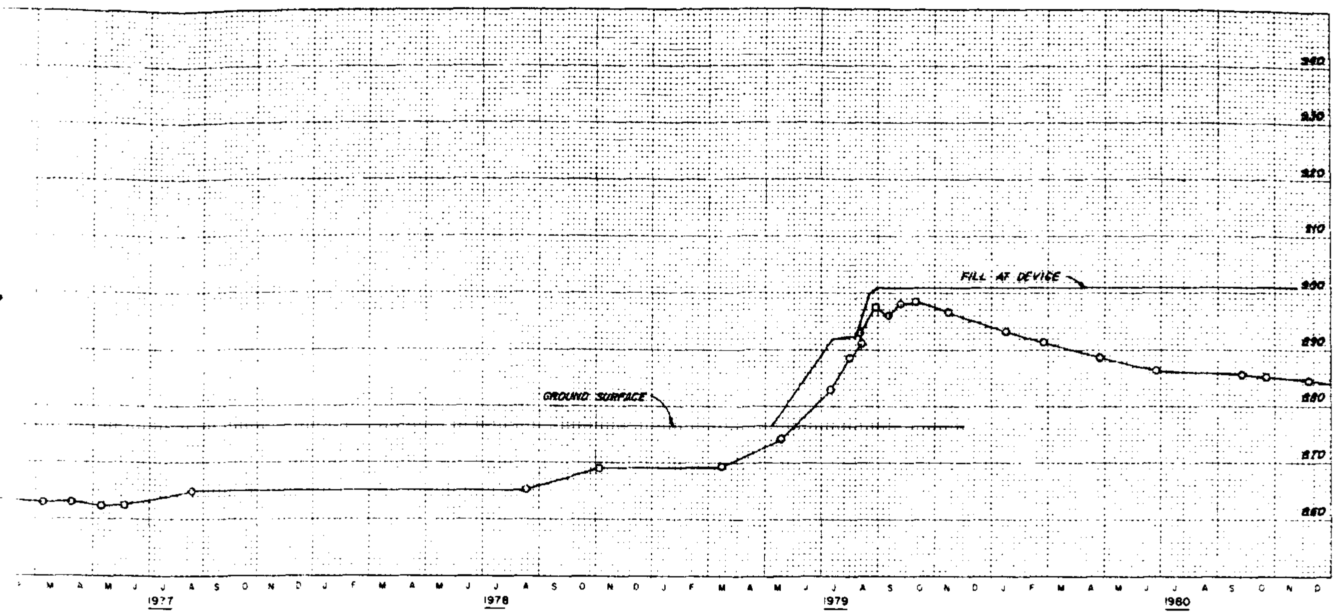
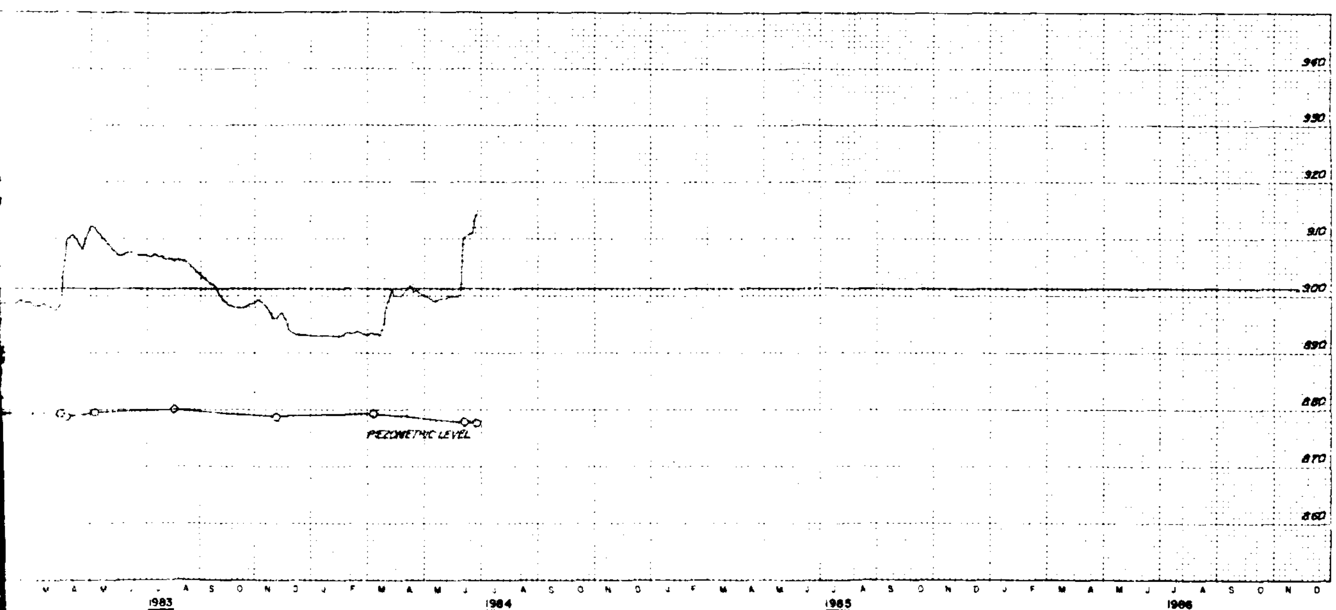
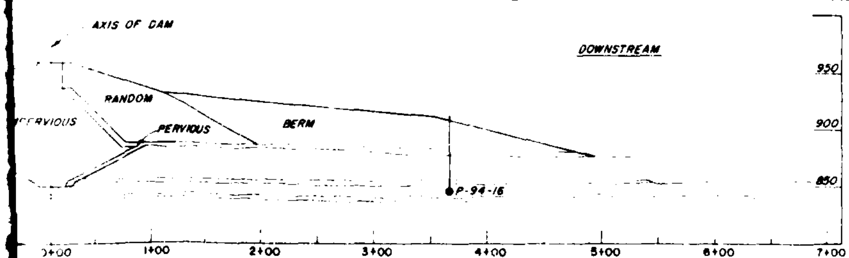
PLATE NO 230


ELEVATION IN FEET BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929
NATURAL GROUND
PIEZOMETRIC LEVEL
GROUND SURFACE
1975
1976
1977
1978
FLOOD CONTROL POOL EL. 931.0
MULTIPURPOSE POOL EL. 917.0
FILL AT DEVICE
POOL EL.
NATURAL GROUND
PIEZOMETRIC LEVEL
1981
1982
1983
1984
AXIS OF DAM
UPSTREAM
DOWNSTREAM
STAGE I EMBANKMENT
STA.82+00 TO 96+00
BERM
RANDOM
IMPERVIOUS
RANDOM
PERVIOUS
BERM
OVERBURDEN
DRUM LIMESTONE
QUIVIRA SHALE
WESTERVILLE LIMESTONE
WEA SHALE
P-94-1E
950
900
850
6+00
5+00
4+00
3+00
2+00
1+00
0+00
1+00
2+00
3+00
4+00
5+00
6+00







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BIG BULL CREEK, KANSAS

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EMBANKMENT CRITERIA REPORT

OPEN TUBE PIEZOMETER
P-94-16

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CORPS OF ENGINEERS U. S. ARMY
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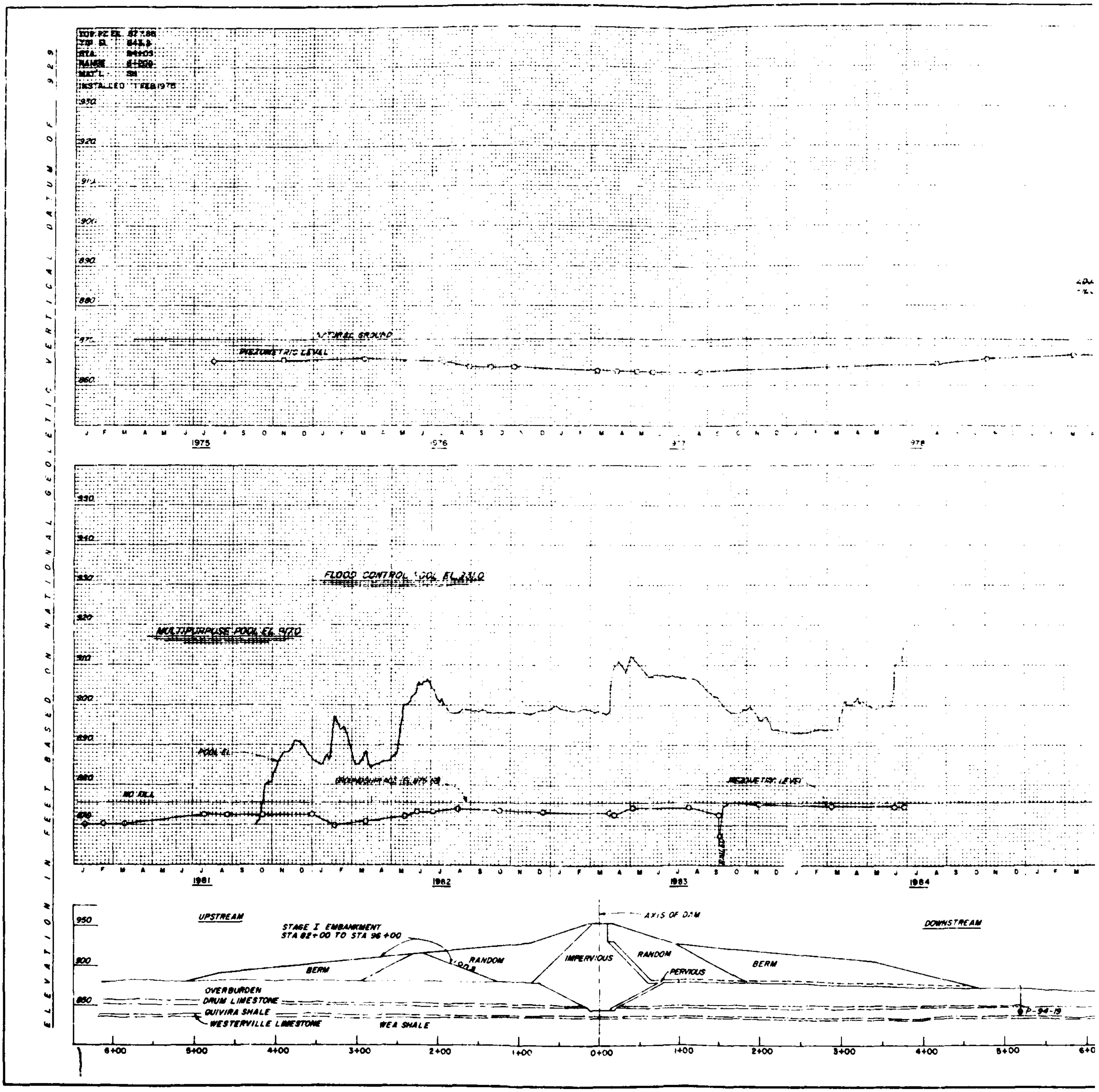
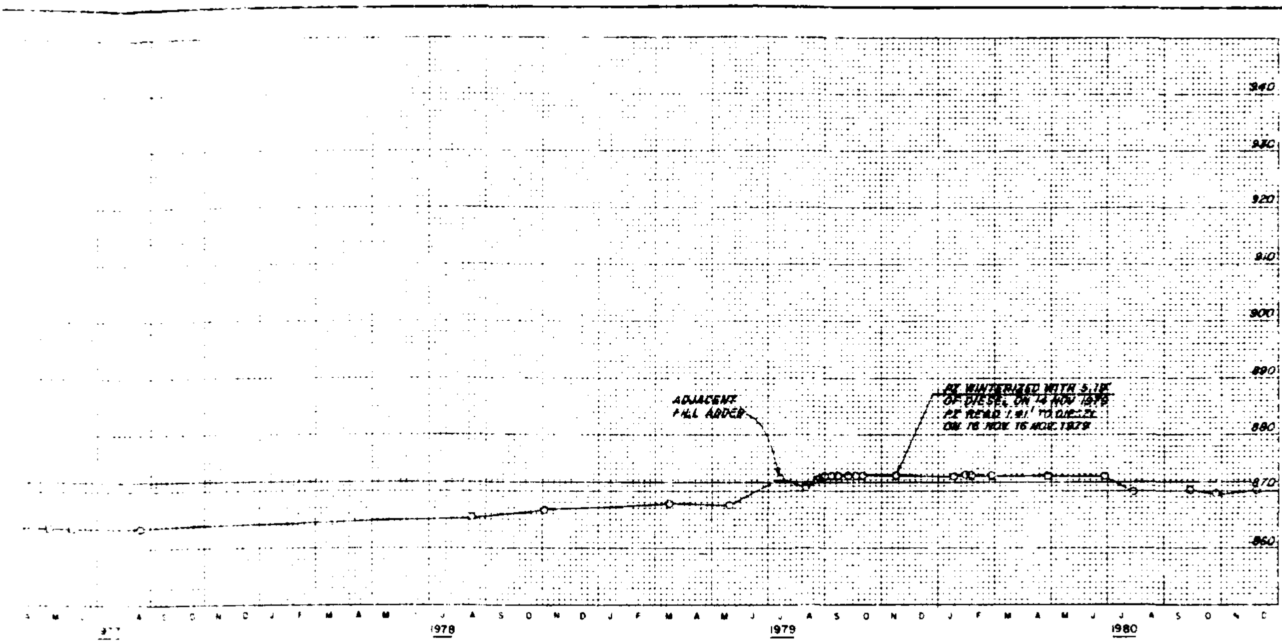
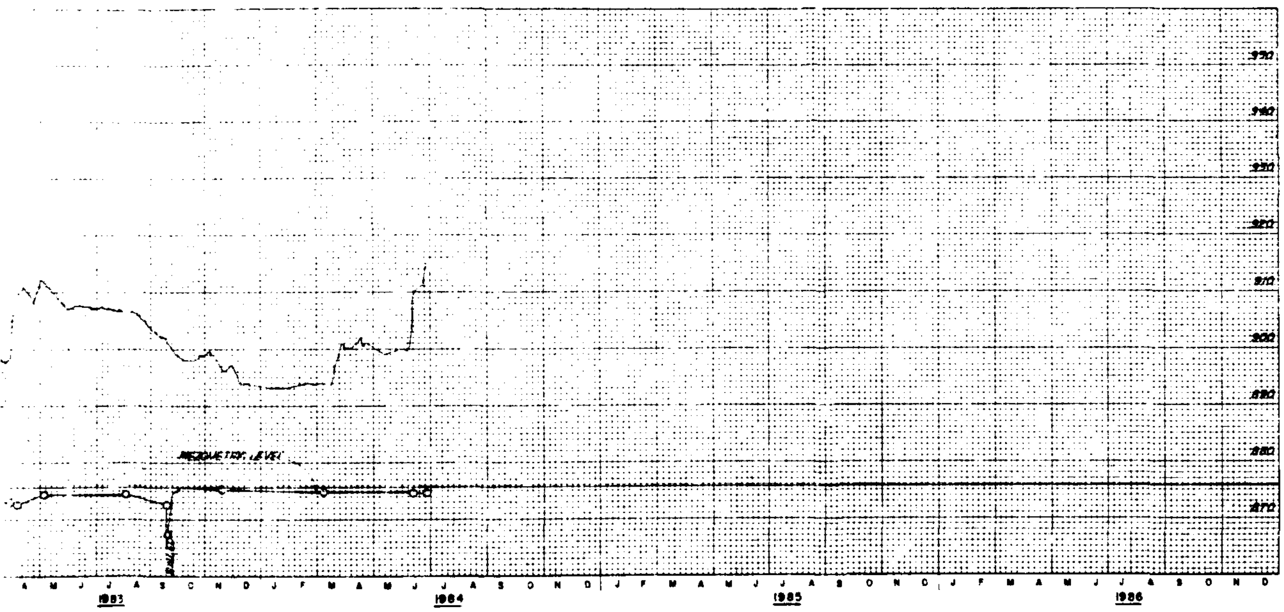
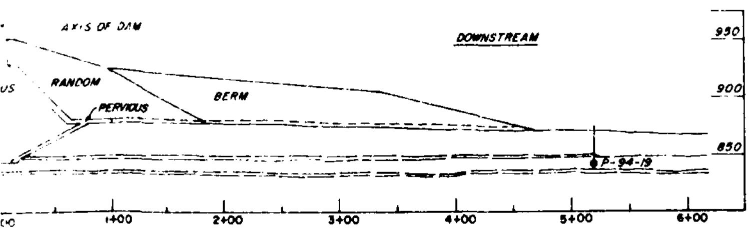
PLATE NO 231


ELEVATION IN FEET BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929
NATURAL GROUND
PIEZOMETRIC LEVEL
1975
MULTIPURPOSE POOL EL
POOL EL
NO FILL
PIEZOMETRIC LEVEL
1981
1982
1983
1984
UPSTREAM
DOWNSTREAM
AXIS OF DAM
STAGE I EMBANKMENT
STA 82+00 TO STA 96+00
BERM
RANDOM
IMPERVIOUS
RANDOM
PERVIOUS
BERM
OVERBURDEN
DRUM LIMESTONE
QUIVIRA SHALE
WESTERVILLE LIMESTONE
WEA SHALE
6+00
5+00
4+00
3+00
2+00
1+00
0+00
1+00
2+00
3+00
4+00
5+00
6+00







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EMBANKMENT CRITERIA REPORT

OPEN TUBE PIEZOMETER P-94-19

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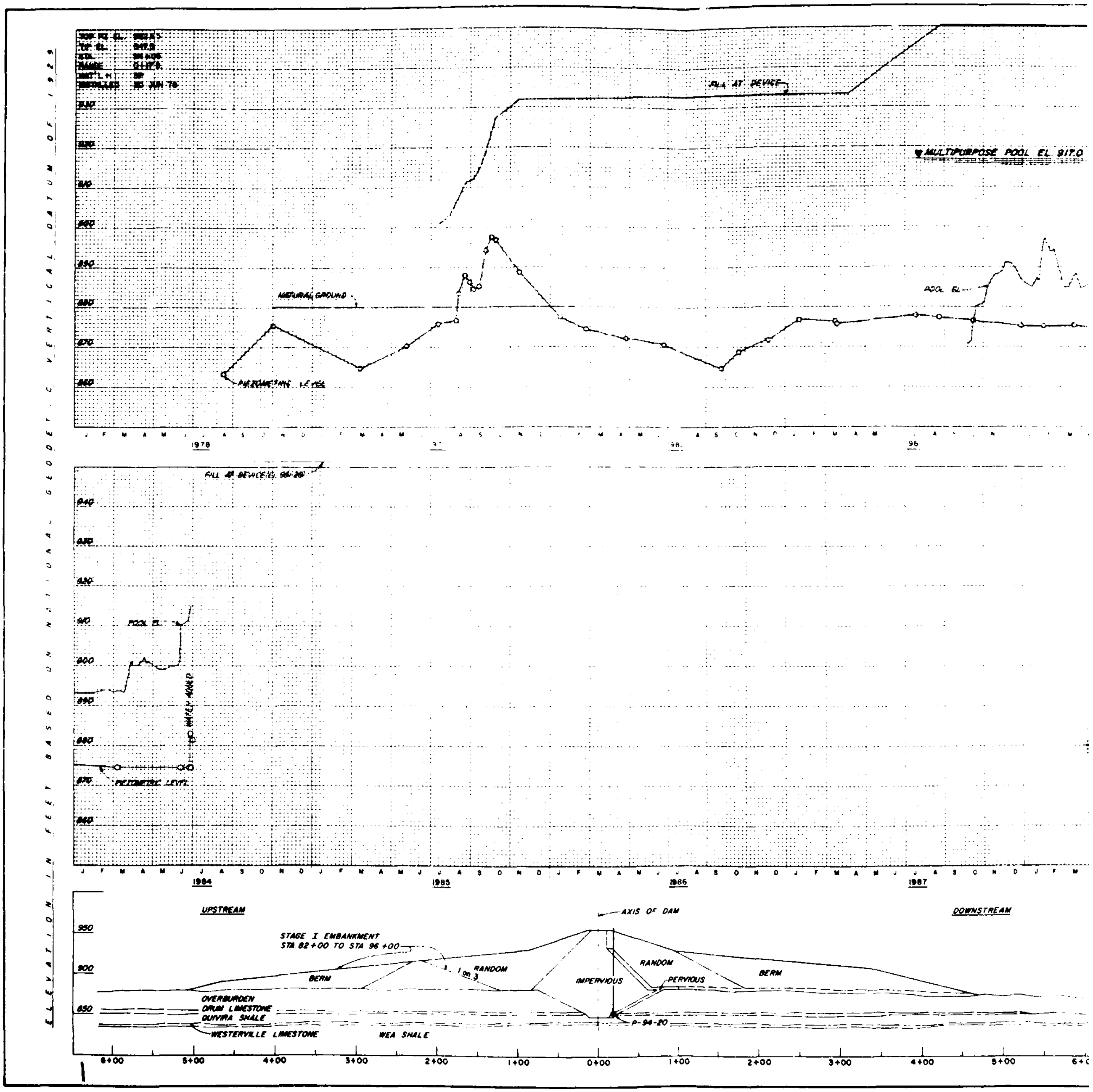
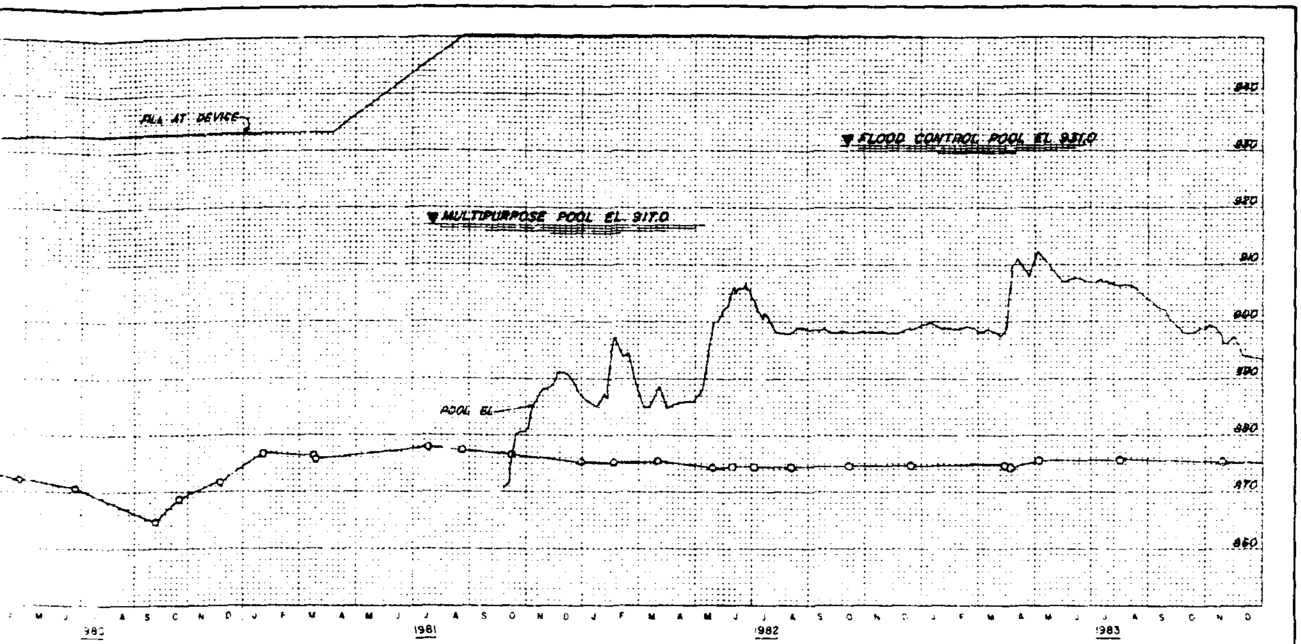
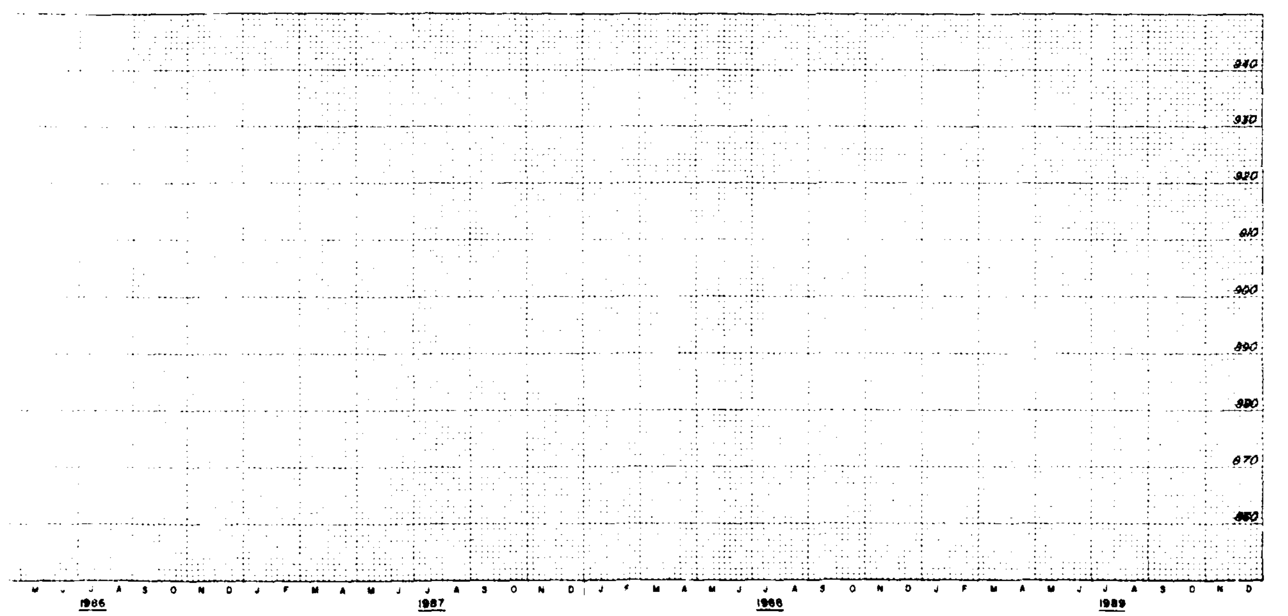
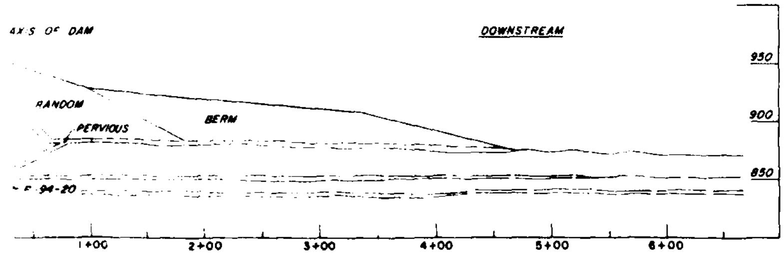
PLATE NO. 234


ELEVATION IN FEET BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929
FILL AT DEVICE
MULTIPURPOSE POOL EL 917.0
NATURAL GROUND
POOL EL
PIEZOMETRIC LEVEL
1978
FILL AT DEVICE
POOL EL
PIEZOMETRIC LEVEL
1984
1985
1986
1987
UPSTREAM
AXIS OF DAM
DOWNSTREAM
STAGE I EMBANKMENT
STA. 82+00 TO STA 96+00
RANDOM
BERM
IMPERVIOUS
RANDOM
PERVIOUS
BERM
OVERBURDEN
DRUM LIMESTONE
QUIVIRA SHALE
WESTERVILLE LIMESTONE
WEA SHALE
P-94-20
950
900
850
6+00
5+00
4+00
3+00
2+00
1+00
0+00
1+00
2+00
3+00
4+00
5+00







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BIG BULL CREEK KANSAS

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OPEN TUBE PIEZOMETER
P-94-20

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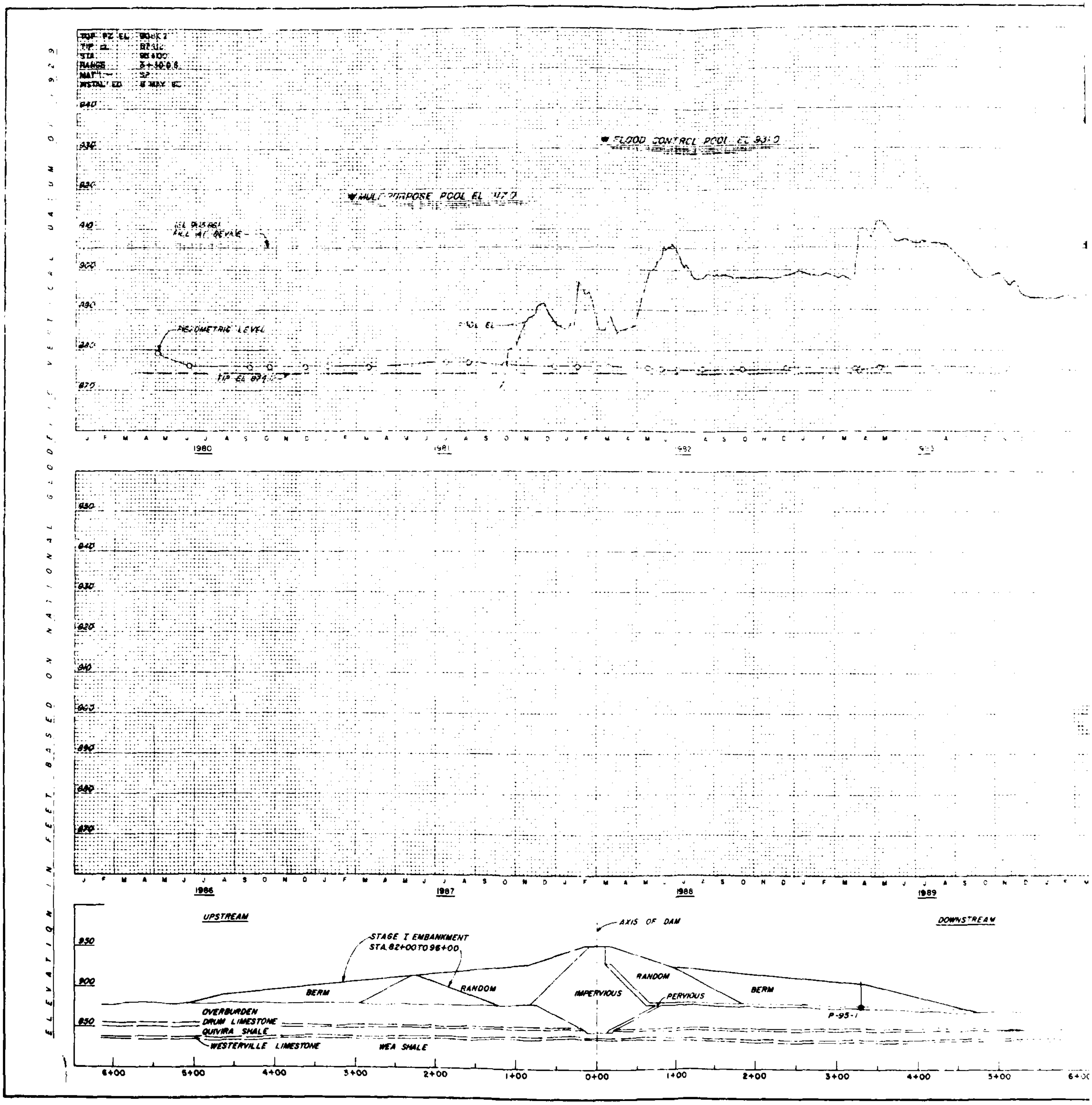
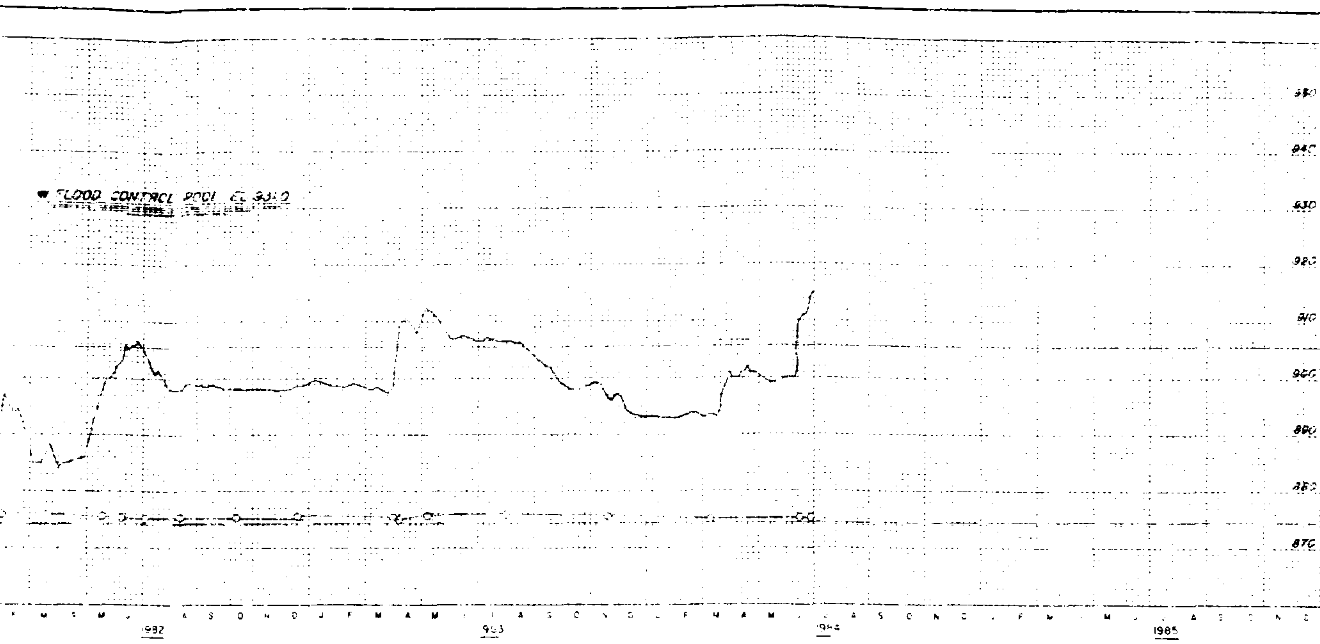
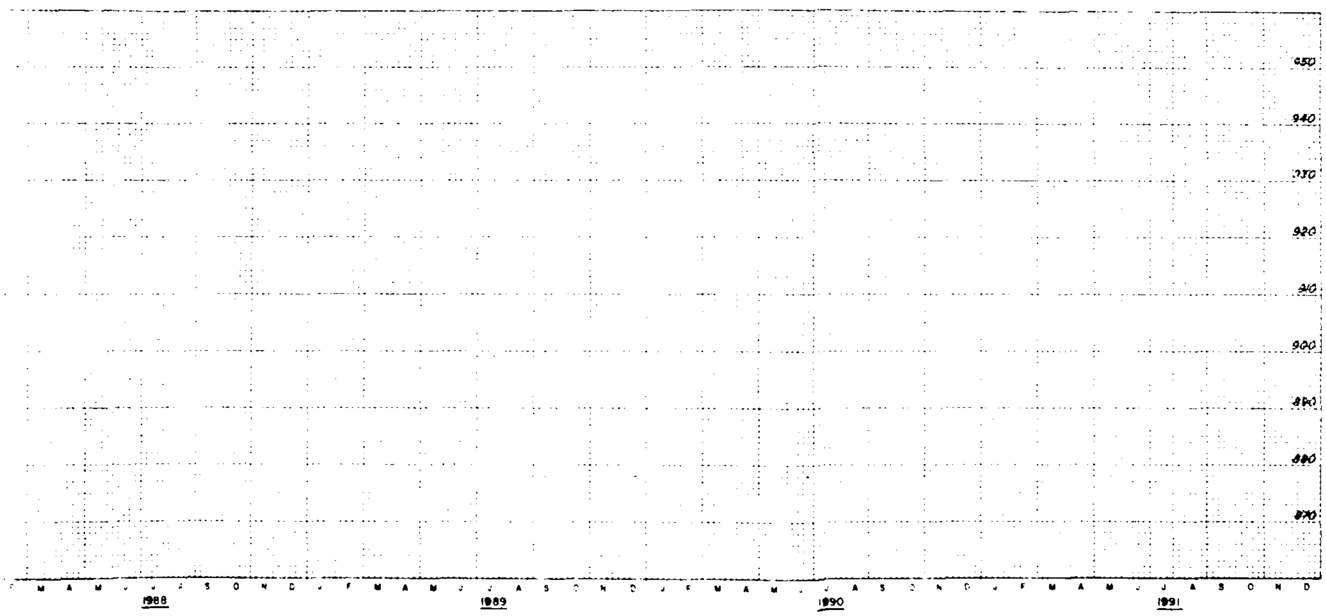
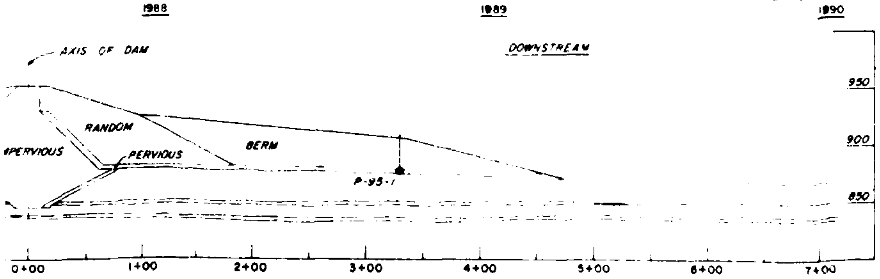
PLATE NO.235


ELEVATION IN FEET, BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929
FLOOD CONTROL POOL EL 931.0
MULTIPURPOSE POOL EL
PIEZOMETRIC LEVEL
POOL EL
TIP EL
1980
1981
1982
1986
1987
1988
1989
UPSTREAM
DOWNSTREAM
AXIS OF DAM
STAGE I EMBANKMENT
STA.82+00 TO 96+00
BERM
RANDOM
IMPERVIOUS
PERVIOUS
OVERBURDEN
DRUM LIMESTONE
QUIVIRA SHALE
WESTERVILLE LIMESTONE
WEA SHALE
P-95-1







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OPEN TUBE PIEZOMETER
P-95-1

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KANSAS CITY DISTRICT

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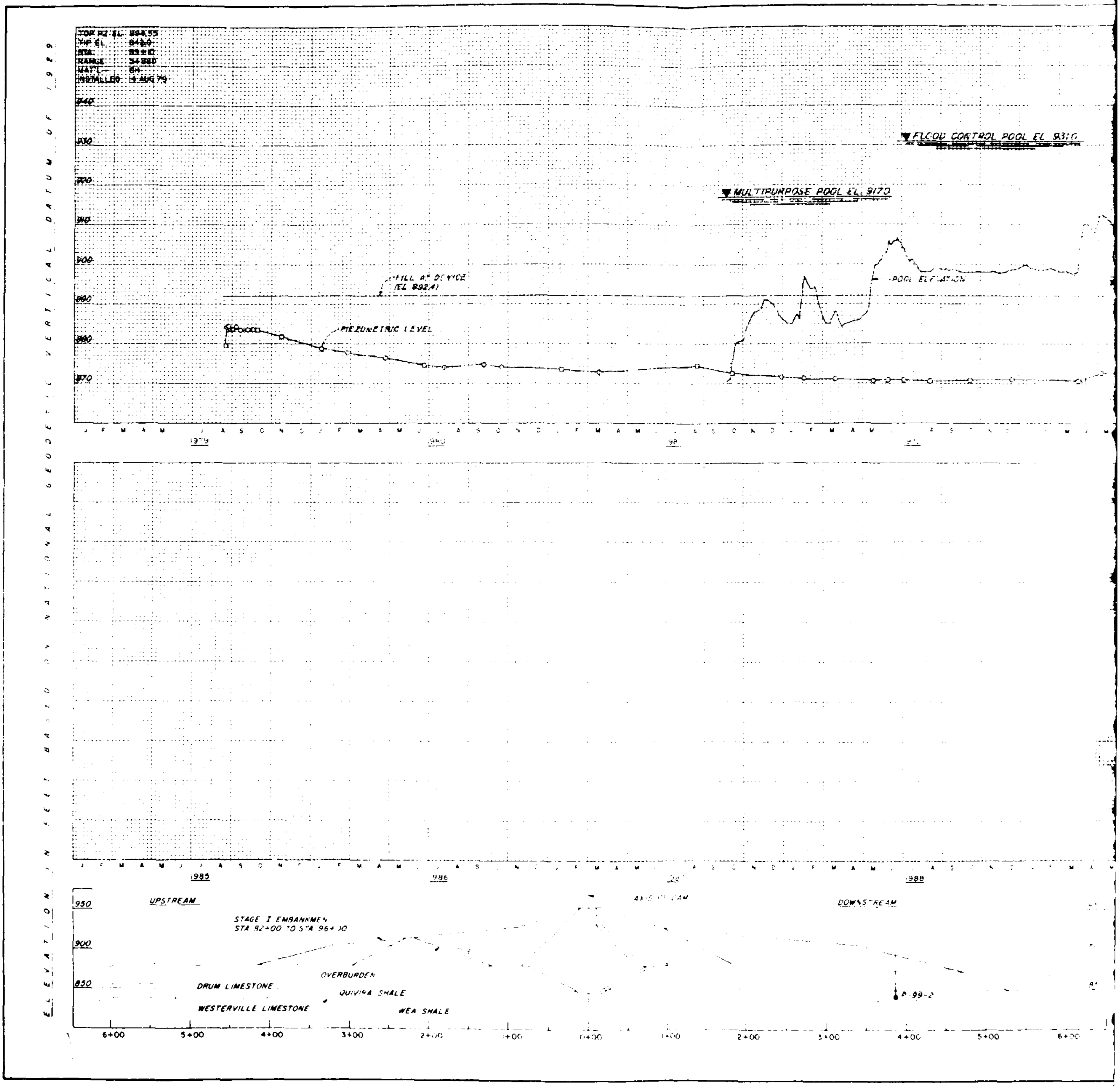
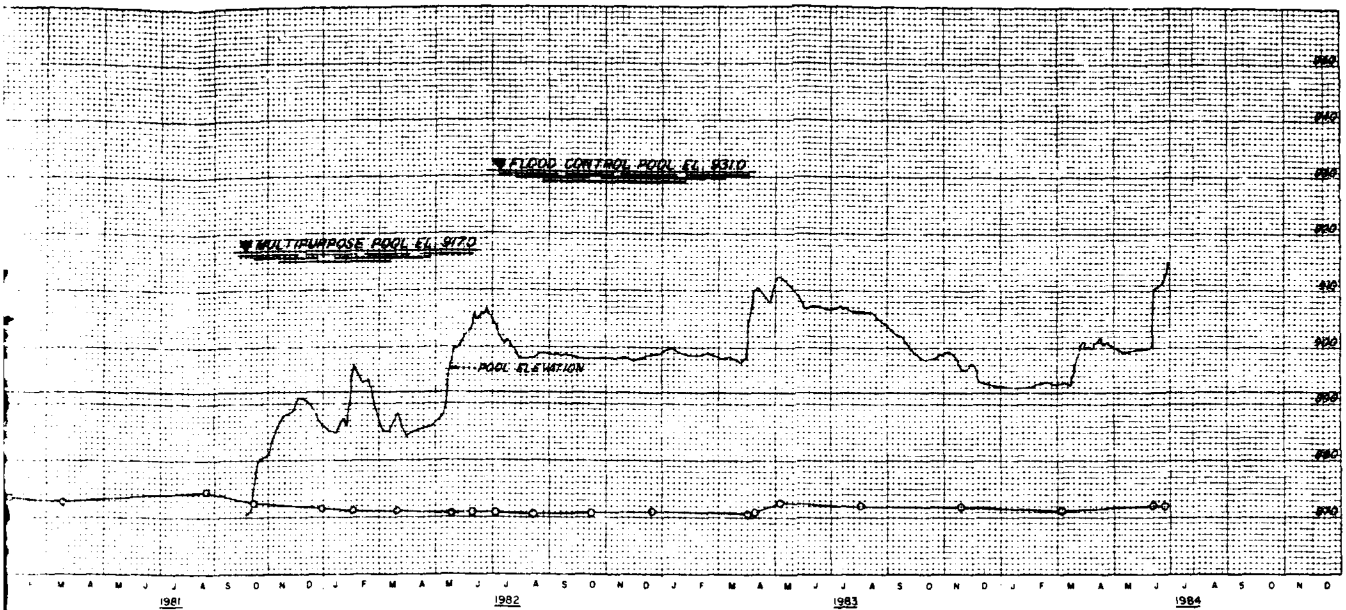
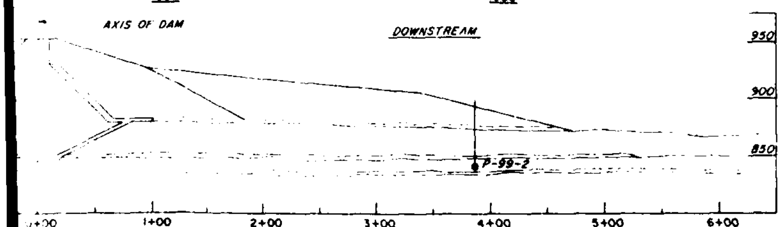
JANUARY 1983

PLATE NO 236


INSTALLED 14 AUG 79
940
930
920
910
900
890
880
870
FLOOD CONTROL POOL EL 931.0
MULTIPURPOSE POOL EL 917.0
FILL AT DEVICE
(EL 892.4)
PIEZOMETRIC LEVEL
POOL ELEVATION
1979
1985
1988
950
900
850
UPSTREAM
STAGE I EMBANKMENT
OVERBURDEN
DRUM LIMESTONE
QUIVIRA SHALE
WESTERVILLE LIMESTONE
WEA SHALE
DOWNSTREAM
6+00
5+00
4+00
3+00
2+00
0+00
2+00
3+00
4+00
5+00





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BIG BULL CREEK, KANSAS

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EMBANKMENT CRITERIA REPORT

OPEN TUBE PIEZOMETER
P-99-2

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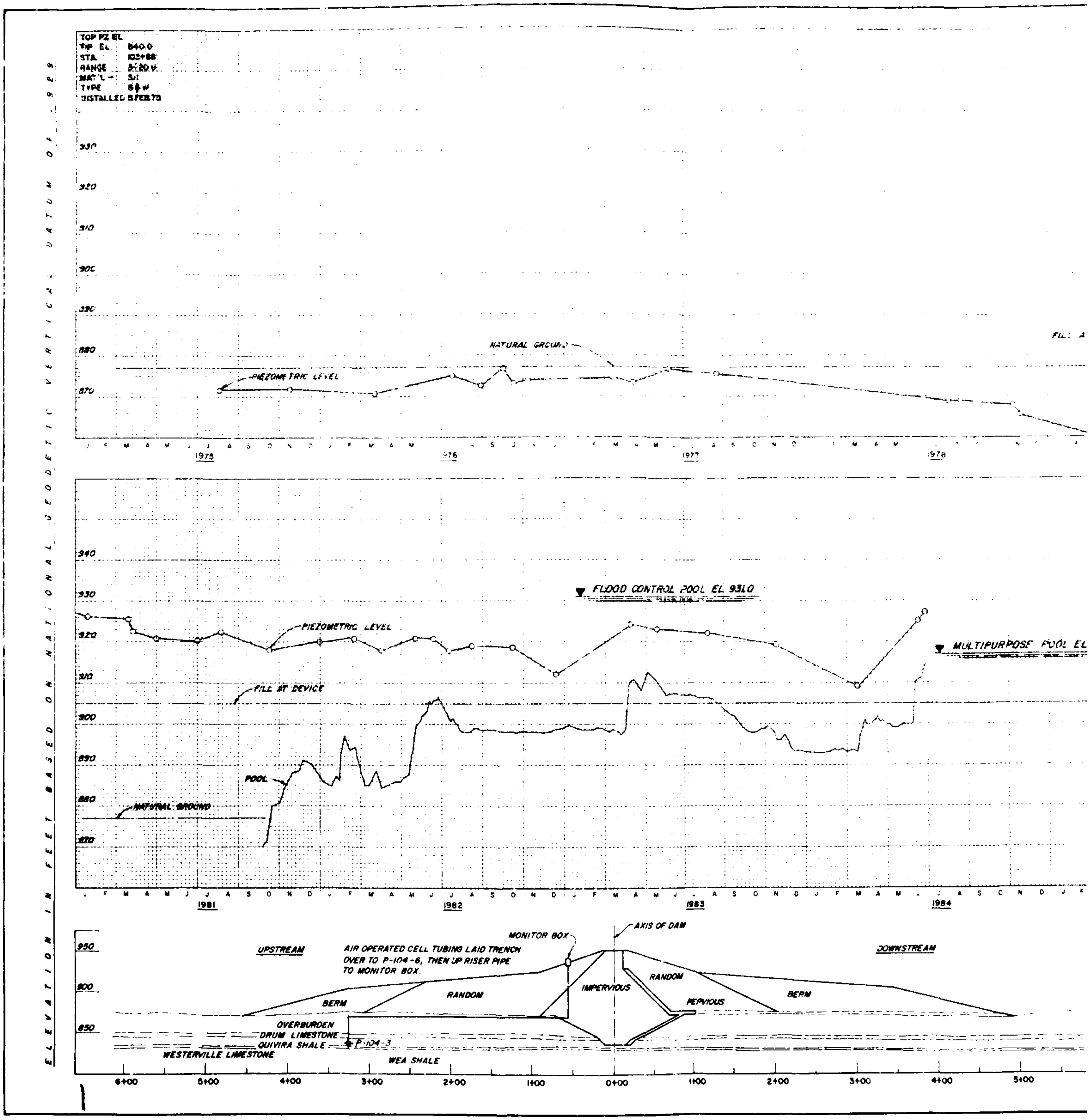
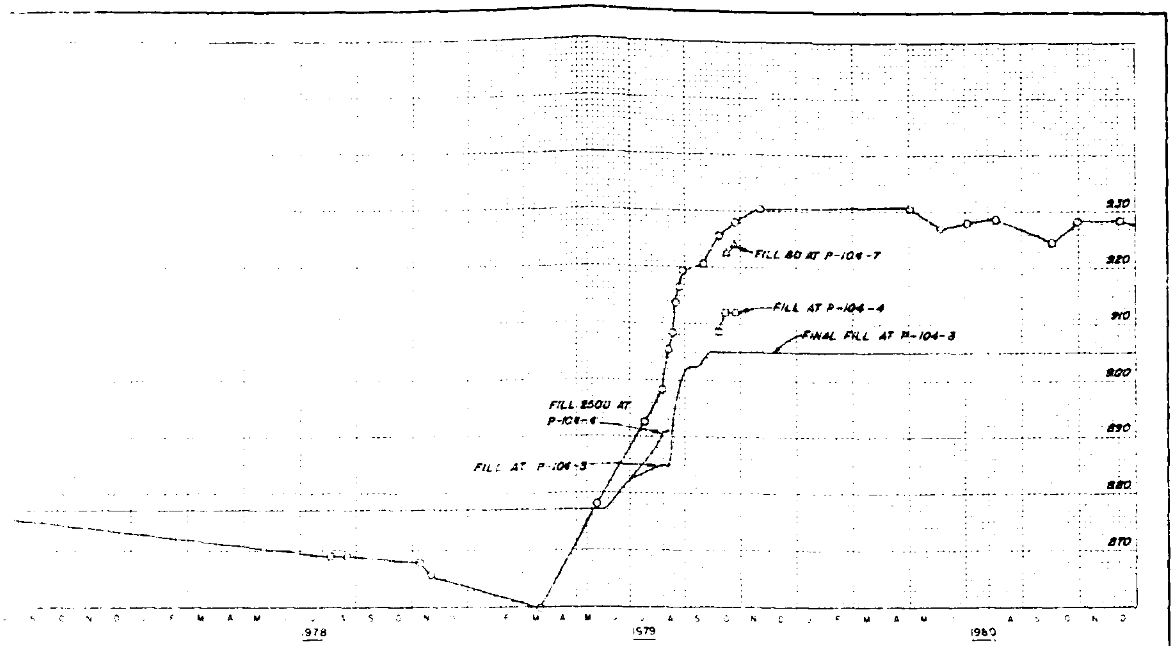
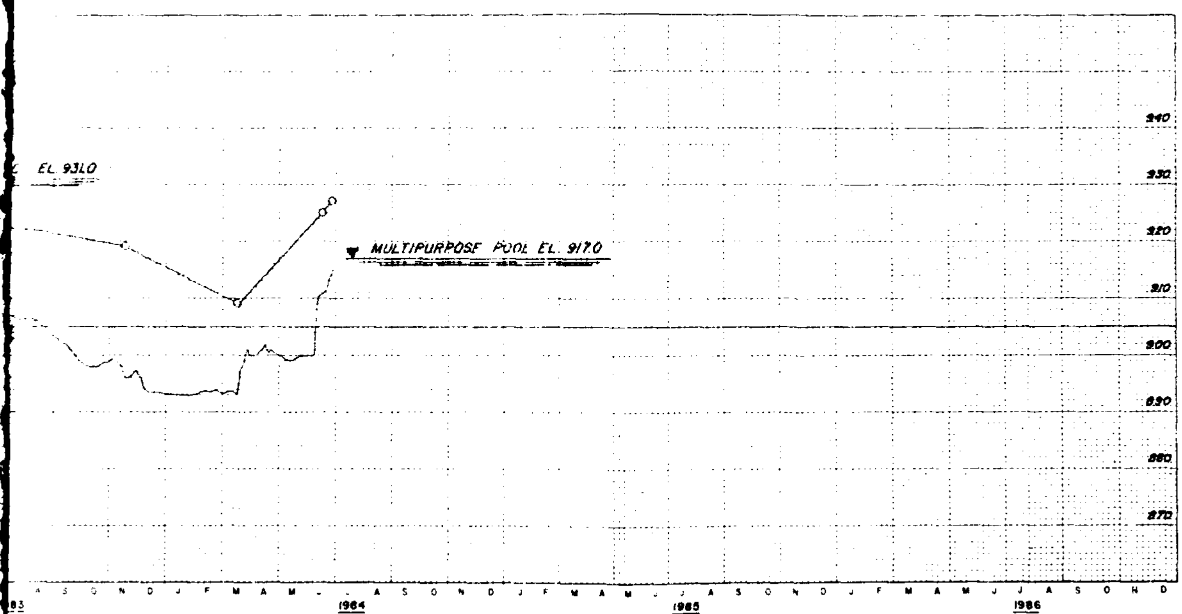
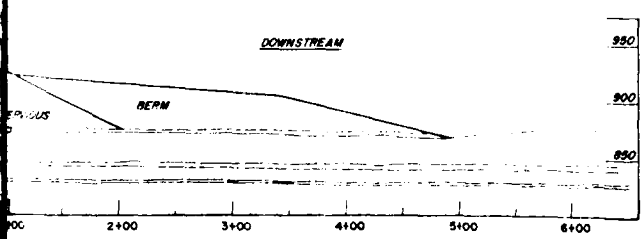
PLATE NO. 237


TOP PZ EL
TIP EL. 840.0
STA. 103+88
RANGE 3-20 U
TYPE
ELEVATION IN FEET BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929
NATURAL GROUND
PIEZOMETRIC LEVEL
1975
1976
1977
1978
FLOOD CONTROL POOL EL 931.0
MULTIPURPOSE POOL EL
PIEZOMETRIC LEVEL
FILL AT DEVICE
POOL
NATURAL GROUND
1981
1982
1983
1984
MONITOR BOX
AXIS OF DAM
UPSTREAM
DOWNSTREAM
AIR OPERATED CELL TUBING LAID TRENCH OVER TO P-104-6, THEN UP RISER PIPE TO MONITOR BOX.
RANDOM
IMPERVIOUS
BERM
PERVIOUS
OVERBURDEN
DRUM LIMESTONE
QUIVIRA SHALE
P-104-3
WESTERVILLE LIMESTONE
WEA SHALE







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AIR CELL PIEZOMETER
P-104-3

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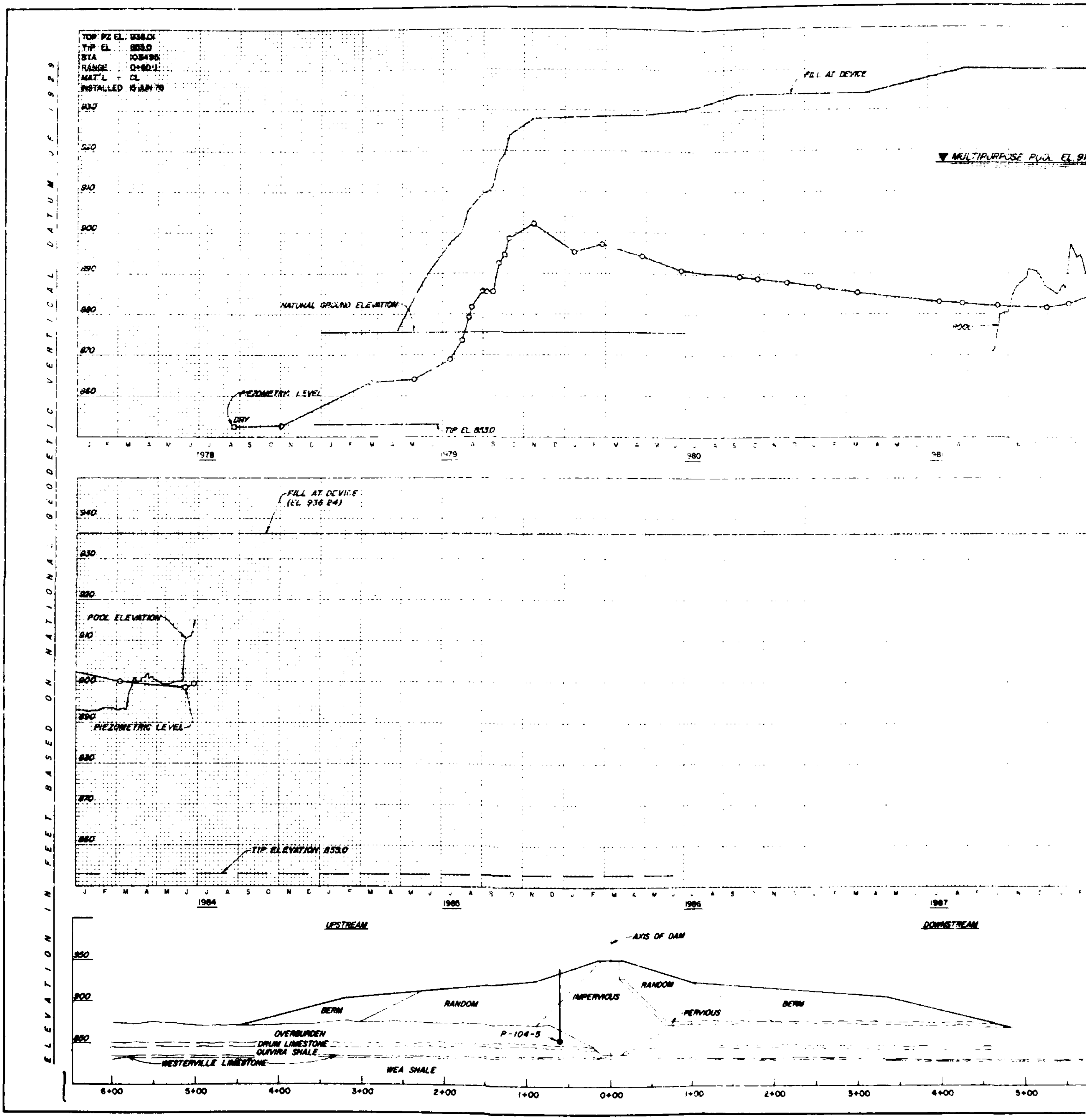
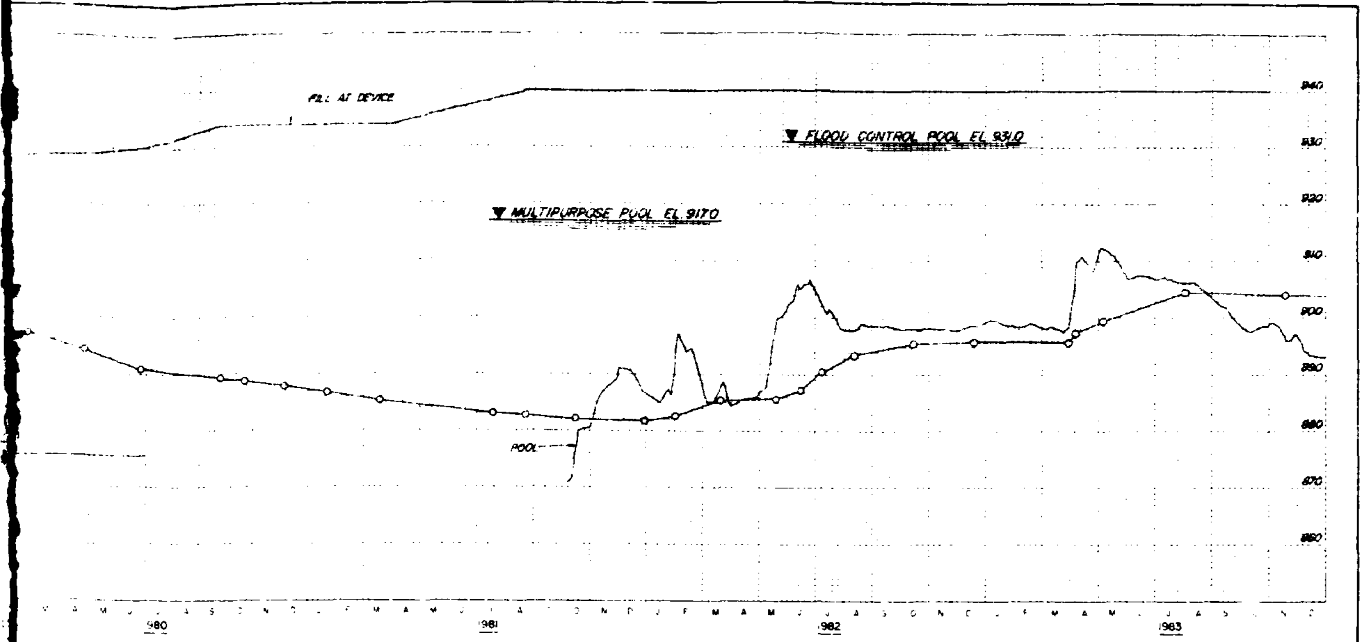
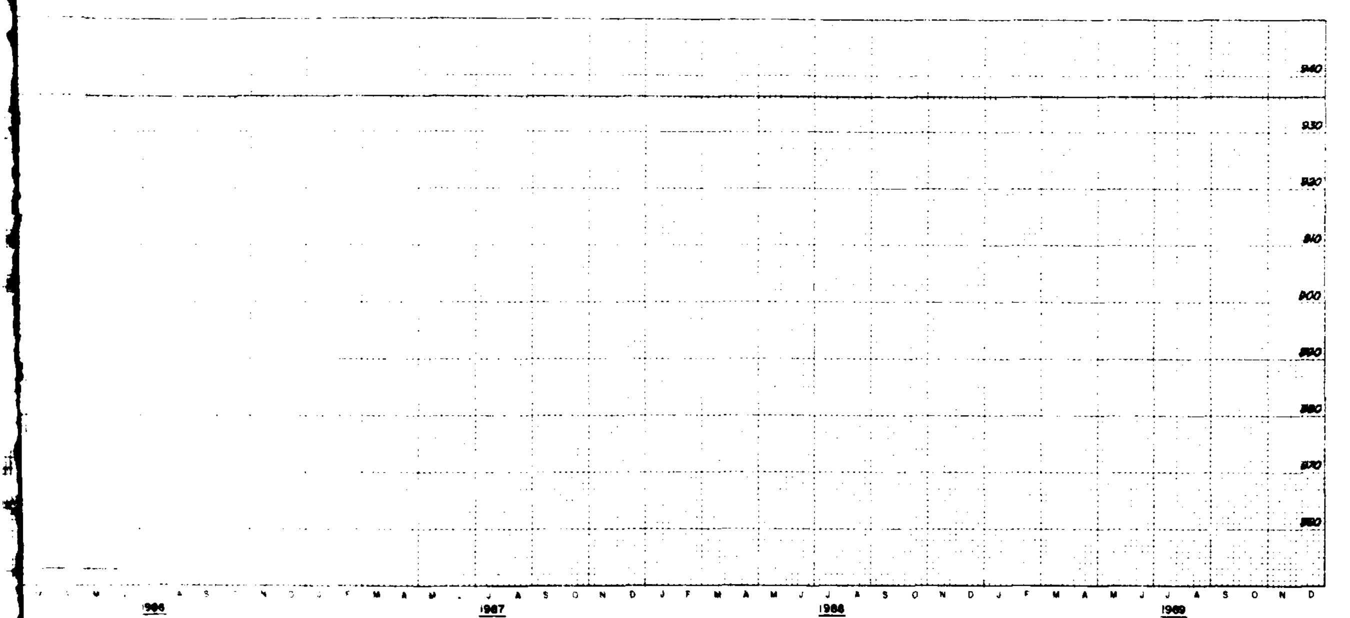
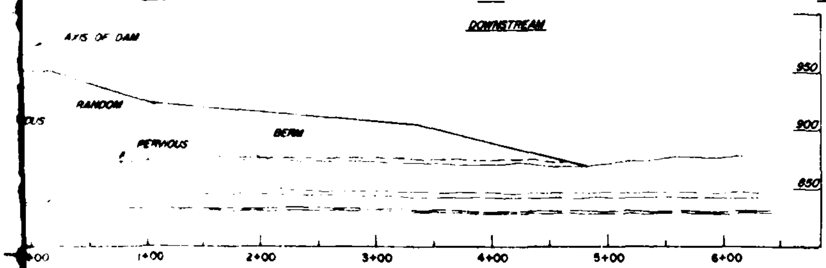
PLATE NO. 242



TOP PZ EL. 938.01
TIP EL. 853.0
STA 103+95
RANGE 0+60 U
MAT'L - CL
INSTALLED 15 JUN 78
FILL AT DEVICE
MULTIPURPOSE POOL EL 91
NATURAL GROUND ELEVATION
PIEZOMETRIC LEVEL
DRY
TIP EL 853.0
POOL
1978
1979
1980
FILL AT DEVICE (EL 936.24)
POOL ELEVATION
PIEZOMETRIC LEVEL
TIP ELEVATION 853.0
1984
1985
1986
1987
ELEVATION IN FEET BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929
UPSTREAM
DOWNSTREAM
AXIS OF DAM
BERM
RANDOM
IMPERVIOUS
RANDOM
PERVIOUS
BERM
OVERBURDEN
DRUM LIMESTONE
QUIVIRA SHALE
WESTERVILLE LIMESTONE
WEA SHALE
P-104-5
6+00
5+00
4+00
3+00
2+00
1+00
0+00
1+00
2+00
3+00
4+00
5+00







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OPEN TUBE PIEZOMETER
P-104-5

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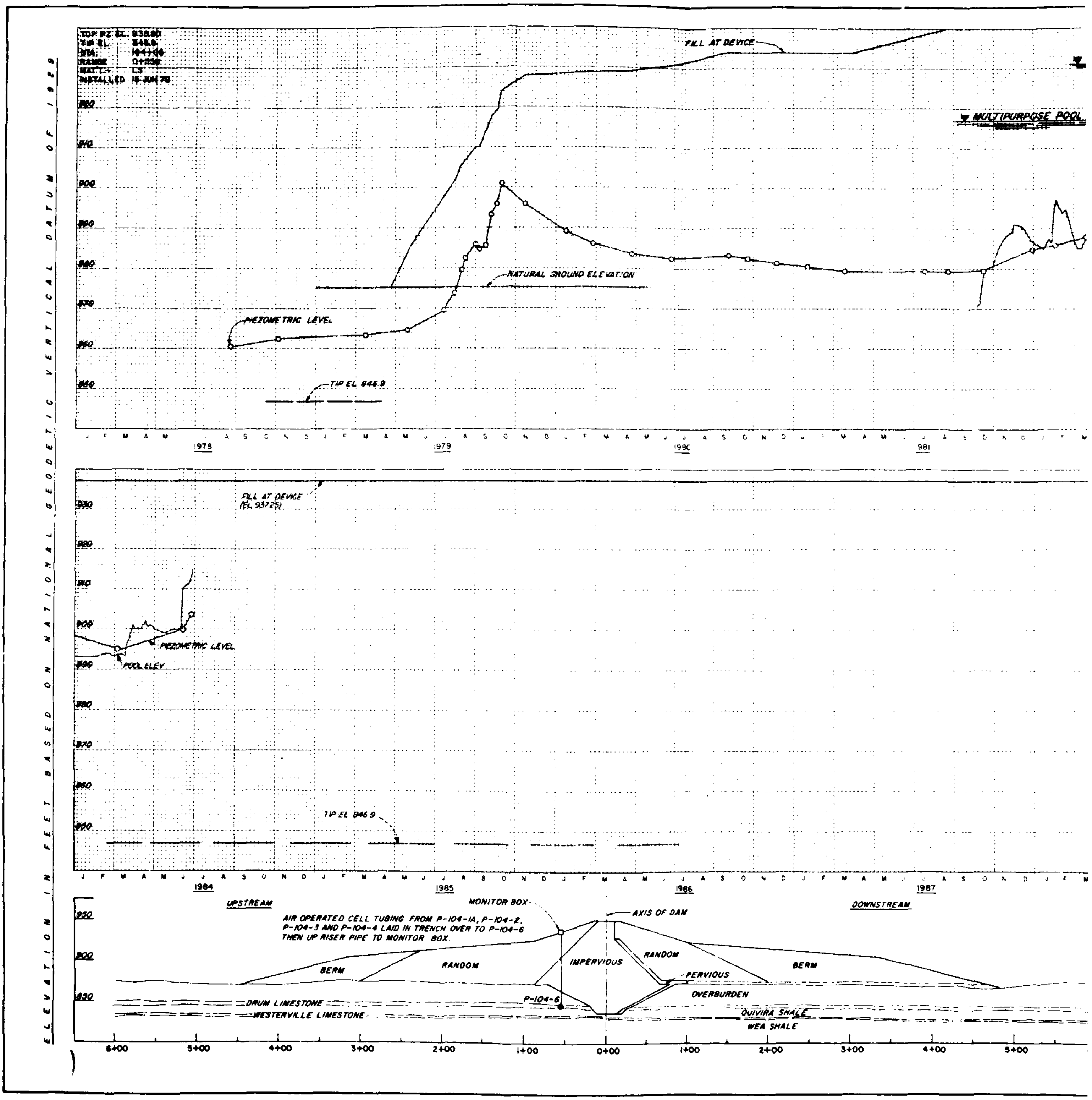
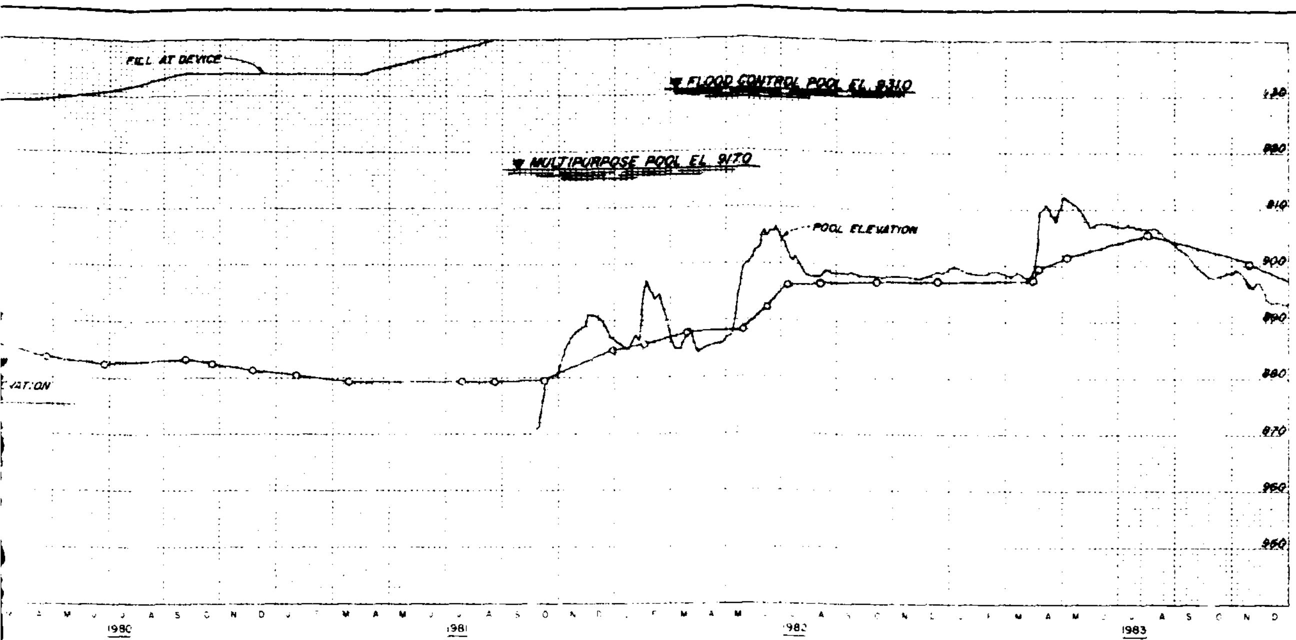
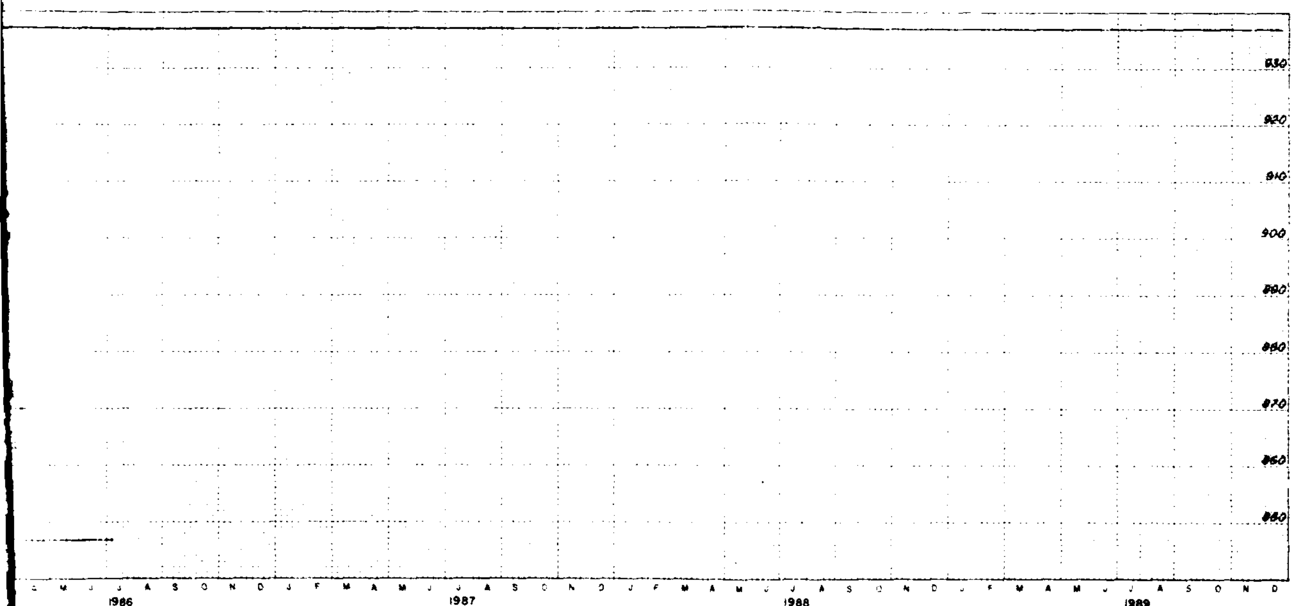
FILE NO. 0-15-974
JANUARY 1983

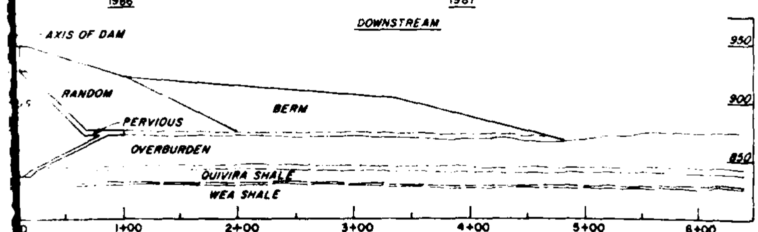
PLATE NO 244



TOP PZ EL.
INSTALLED
FILL AT DEVICE
MULTIPURPOSE POOL
PIEZOMETRIC LEVEL
NATURAL GROUND ELEVATION
TIP EL 846.9
1978
1979
1980
1981
FILL AT DEVICE (EL 937.25)
PIEZOMETRIC LEVEL
POOL ELEV
TIP EL 846.9
1984
1985
1986
1987
ELEVATION IN FEET BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929
UPSTREAM
MONITOR BOX
AXIS OF DAM
DOWNSTREAM
AIR OPERATED CELL TUBING FROM P-104-1A, P-104-2, P-104-3 AND P-104-4 LAID IN TRENCH OVER TO P-104-6 THEN UP RISER PIPE TO MONITOR BOX.
BERM
RANDOM
IMPERVIOUS
RANDOM
PERVIOUS
BERM
OVERBURDEN
P-104-6
DRUM LIMESTONE
WESTERVILLE LIMESTONE
QUIVIRA SHALE
WEA SHALE
950
900
850
6+00
5+00
4+00
3+00
2+00
1+00
0+00
1+00
2+00
3+00
4+00
5+00







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BIG BULL CREEK, KANSAS

HILLSDALE LAKE

EMBANKMENT CRITERIA REPORT

OPEN TUBE PIEZOMETER
P-104-6

In 1 sheet | Sheet No. 1 | Scale as shown

CORPS OF ENGINEERS U. S. ARMY
KANSAS CITY DISTRICT

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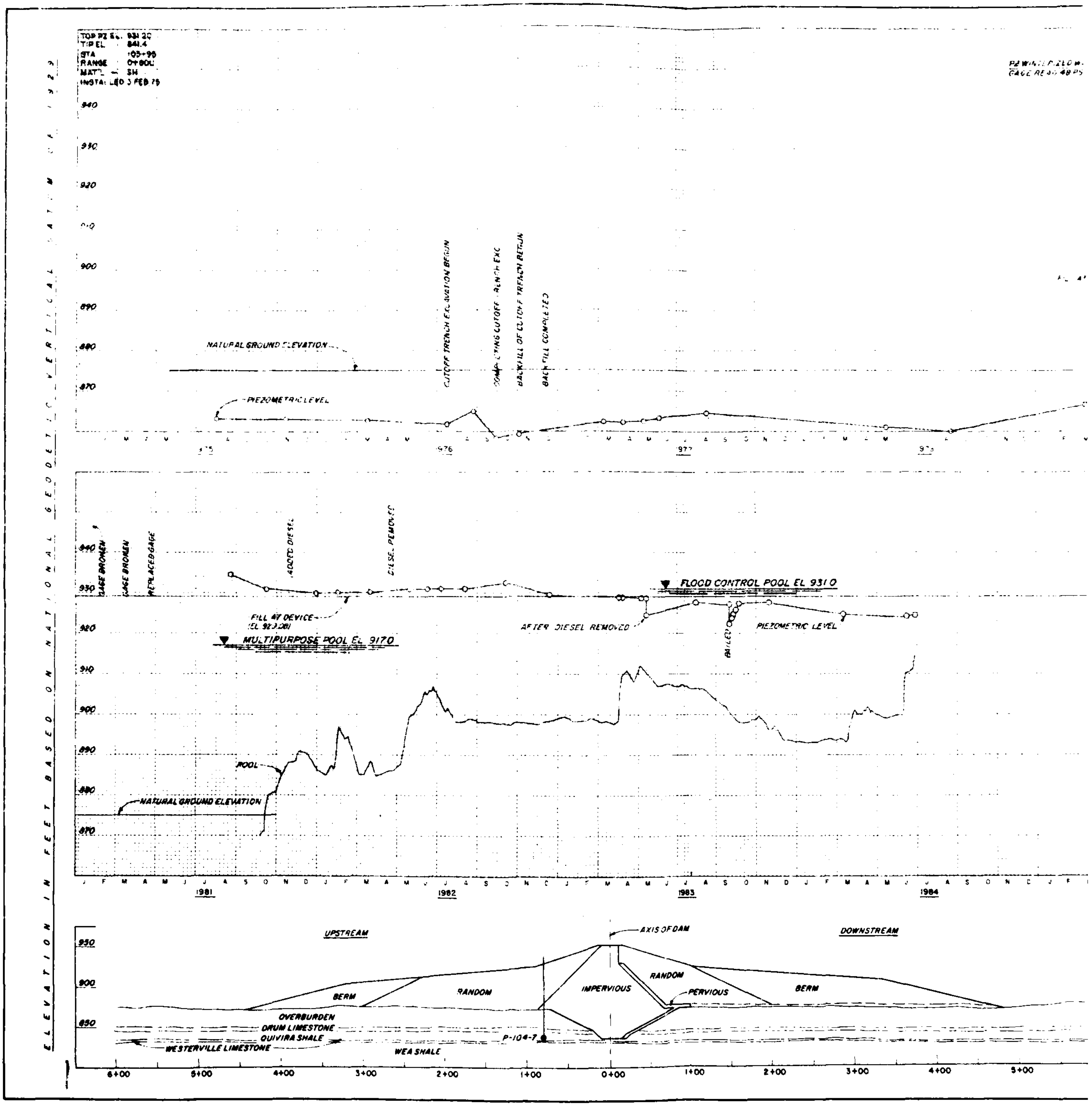
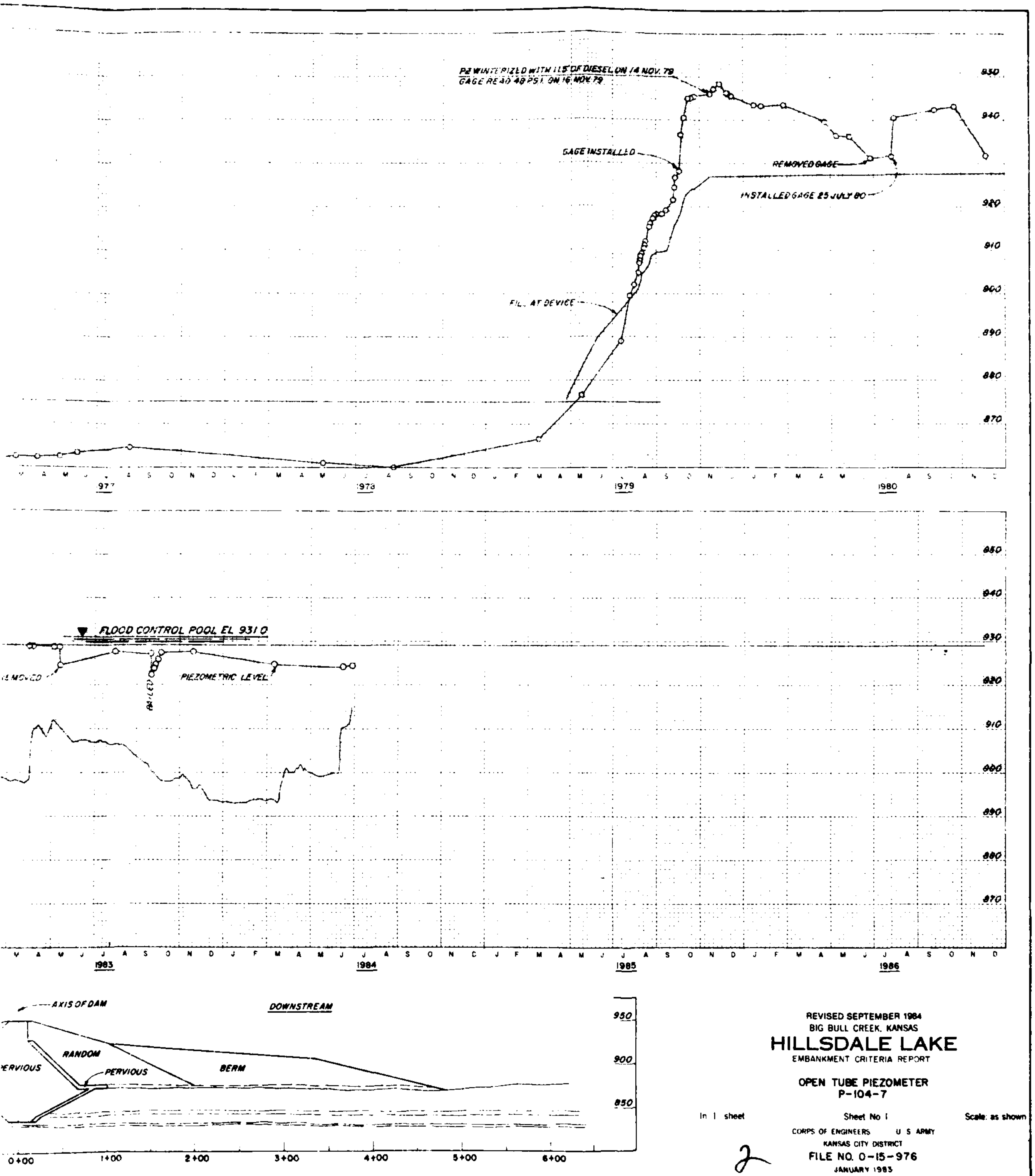
FILE NO. O-15-975
JANUARY 1983

PLATE NO 245



TOP PZ EL 931.20
TIP EL 841.4
STA 105+95
RANGE 0+00U
MAT'L SH
INSTALLED 3 FEB 75
NATURAL GROUND ELEVATION
PIEZOMETRIC LEVEL
CUTOFF TRENCH EXCAVATION BEGUN
BACKFILL OF CUTOFF TRENCH BEGUN
BACKFILL COMPLETED
1976
1977
GAGE BROKEN
GAGE BROKEN
REPLACED GAGE
ADDED DIESEL
DIESEL REMOVED
FILL AT DEVICE
FLOOD CONTROL POOL EL 931.0
MULTIPURPOSE POOL EL 917.0
AFTER DIESEL REMOVED
BAILED
PIEZOMETRIC LEVEL
POOL
NATURAL GROUND ELEVATION
1981
1982
1983
1984
UPSTREAM
AXIS OF DAM
DOWNSTREAM
BERM
RANDOM
IMPERVIOUS
RANDOM
PERVIOUS
BERM
OVERBURDEN
DRUM LIMESTONE
QUIVIRA SHALE
WESTERVILLE LIMESTONE
WEA SHALE
P-104-7
6+00
5+00
4+00
3+00
2+00
1+00
0+00
1+00
2+00
3+00
4+00
5+00
ELEVATION IN FEET BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929



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BIG BULL CREEK, KANSAS

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EMBANKMENT CRITERIA REPORT

OPEN TUBE PIEZOMETER
P-104-7

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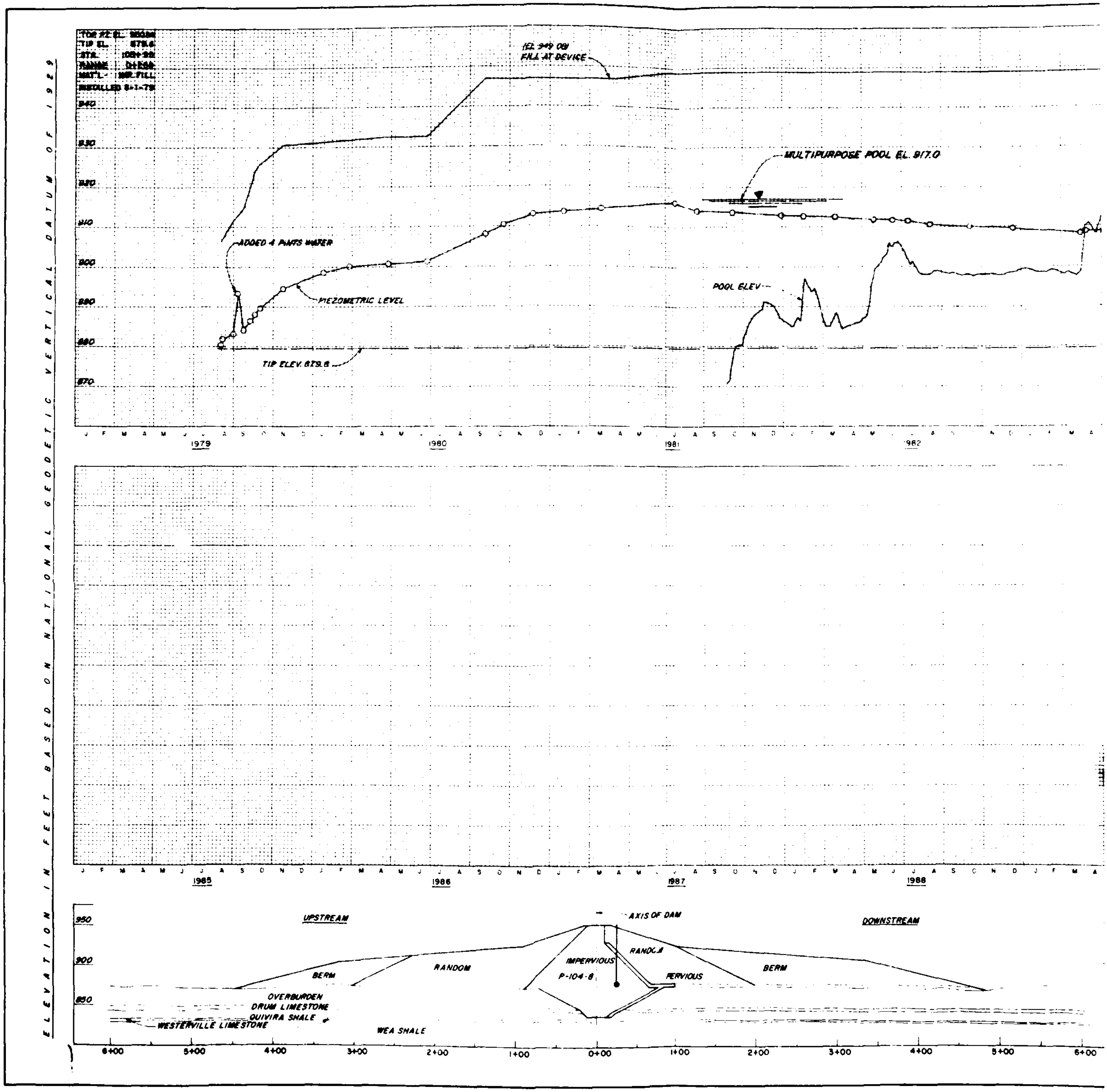
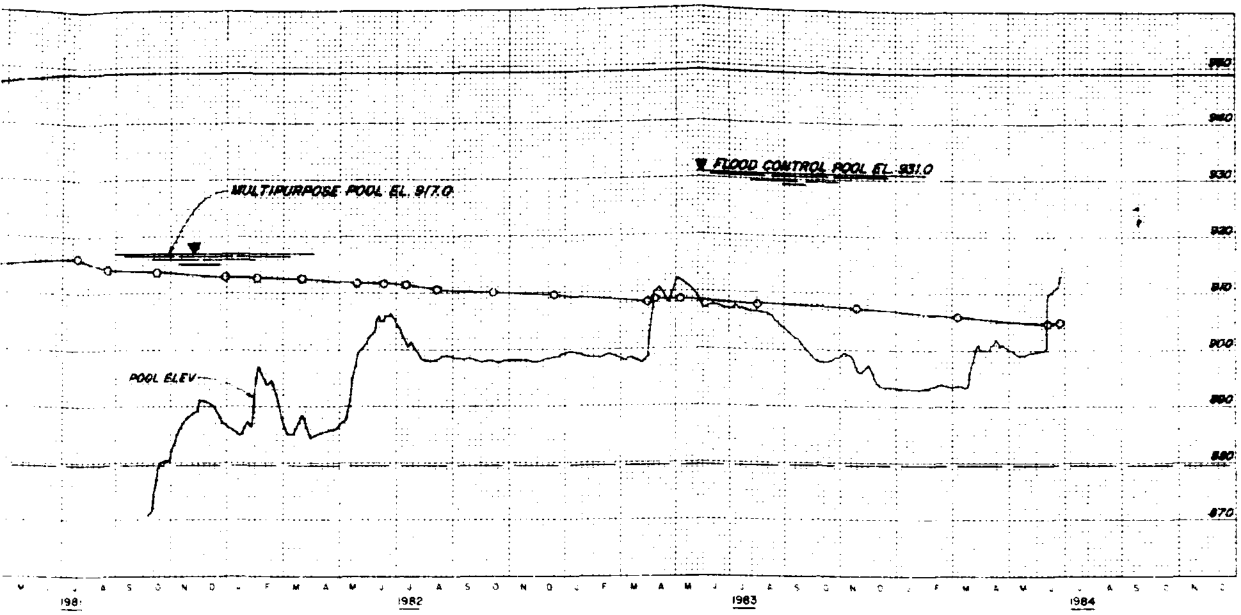
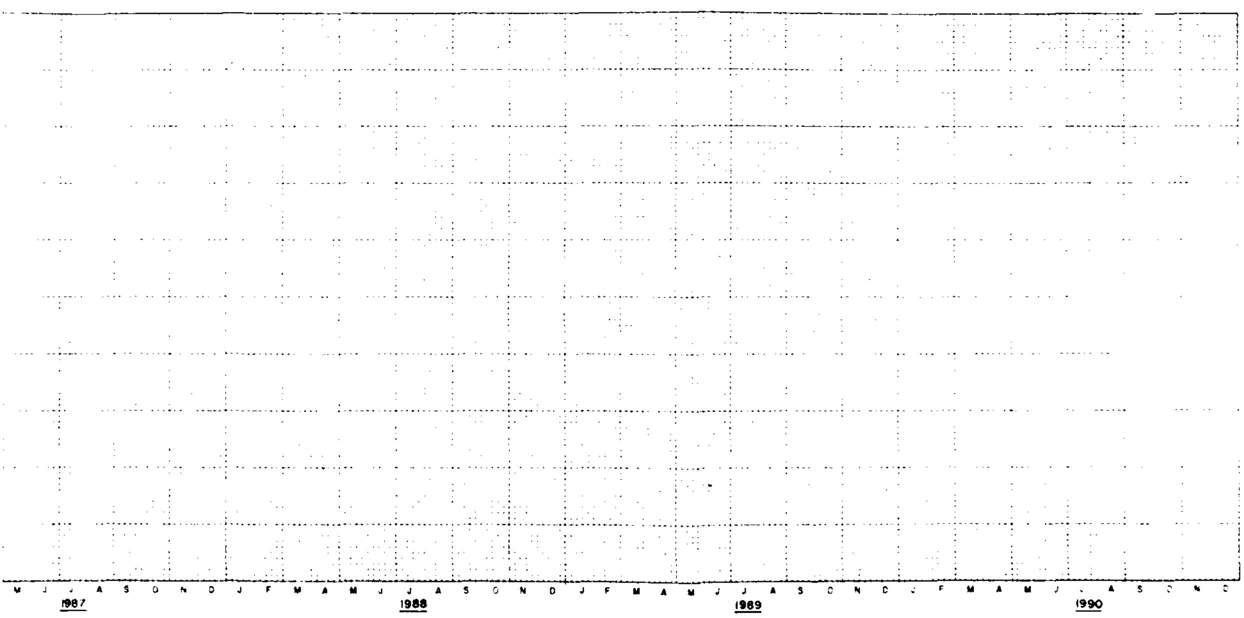
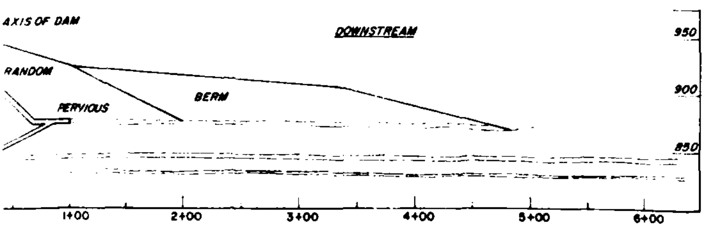
KANSAS CITY DISTRICT
FILE NO. 0-15-976
JANUARY 1985


ELEVATION IN FEET BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929
TIP EL.
(EL. 949.0)
FILL AT DEVICE
MULTIPURPOSE POOL EL. 917.0
ADDED 4 PINTS WATER
PIEZOMETRIC LEVEL
POOL ELEV.
TIP ELEV. 879.8
940
930
920
910
900
890
880
870
1979
1980
1981
1982
1985
1986
1987
1988
UPSTREAM
AXIS OF DAM
DOWNSTREAM
RANDOM
IMPERVIOUS
P-104-8
PERVIOUS
BERM
OVERBURDEN
DRUM LIMESTONE
QUIVIRA SHALE
WESTERVILLE LIMESTONE
WEA SHALE
950
900
850
6+00
5+00
4+00
3+00
2+00
1+00
0+00
1+00
2+00
3+00
4+00
5+00
6+00







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EMBANKMENT CRITERIA REPORT

OPEN TUBE PIEZOMETER
P-104-8

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FILE NO. 0-15-977
JANUARY 1983

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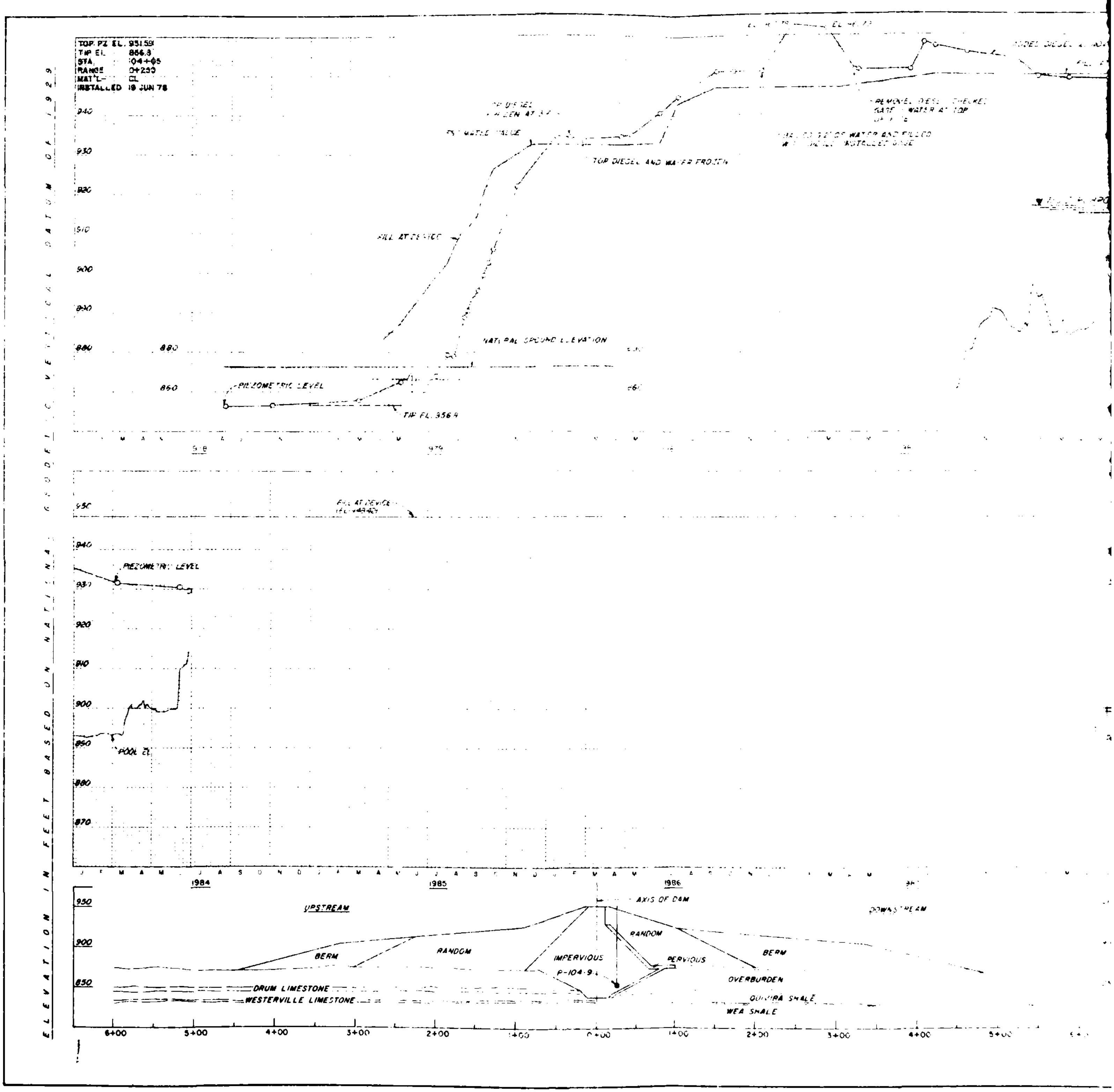
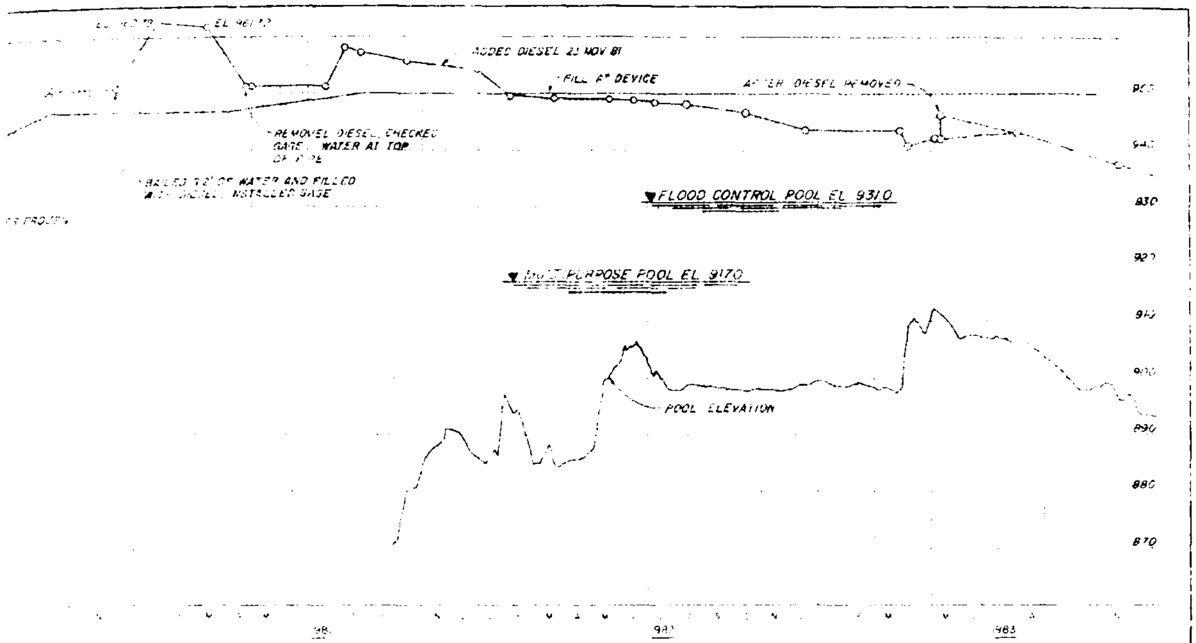
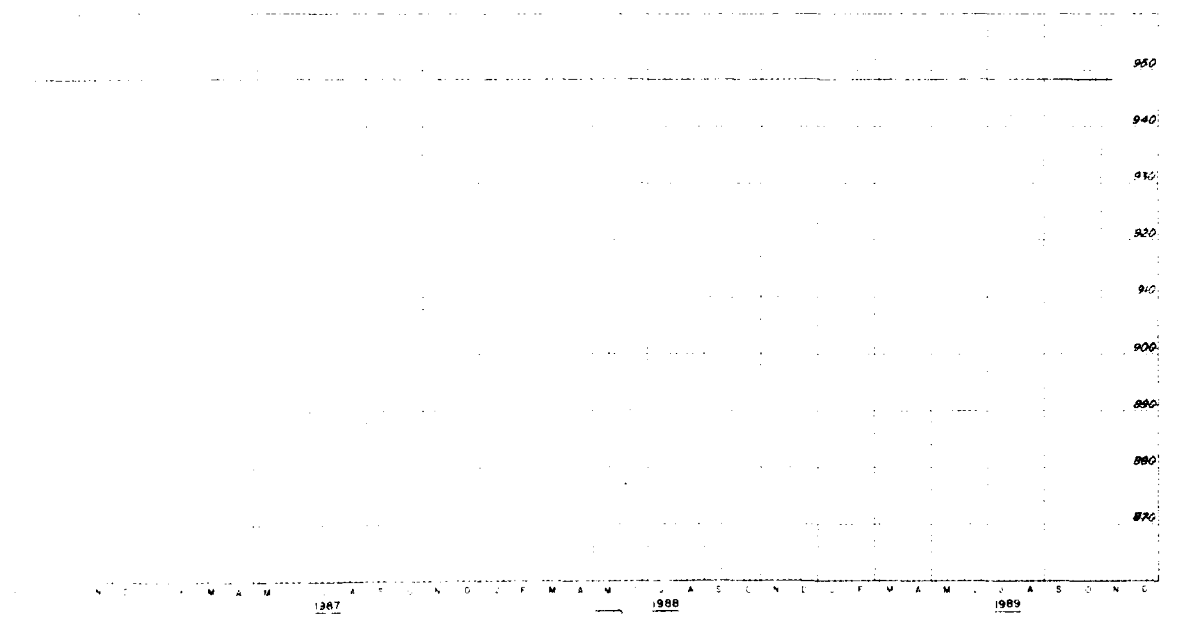
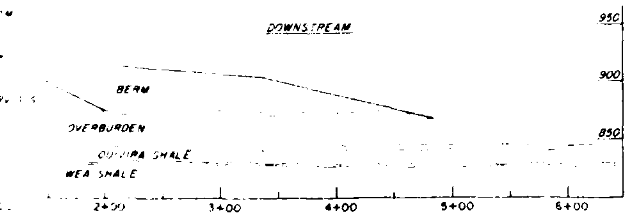
PLATE NO 247



TOP PZ EL. 951.59
TIP EL 866.3
STA. 104+05
RANGE 0+250
MAT'L- CL
INSTALLED 19 JUN 78
ESTIMATED VALUE
FILL AT DEVICE
NATURAL GROUND ELEVATION
PIEZOMETRIC LEVEL
TOP DIESEL AND WATER FROZEN
POOL EL
1984
1985
1986
ELEVATION IN FEET BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929
UPSTREAM
DOWNSTREAM
AXIS OF DAM
BERM
RANDOM
IMPERVIOUS
PERVIOUS
P-104-9.1
OVERBURDEN
DRUM LIMESTONE
WESTERVILLE LIMESTONE
QUIVIRA SHALE
WEA SHALE
6+00
5+00
4+00
3+00
2+00
1+00
0+00







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OPEN TUBE PIEZOMETER
P-104-9

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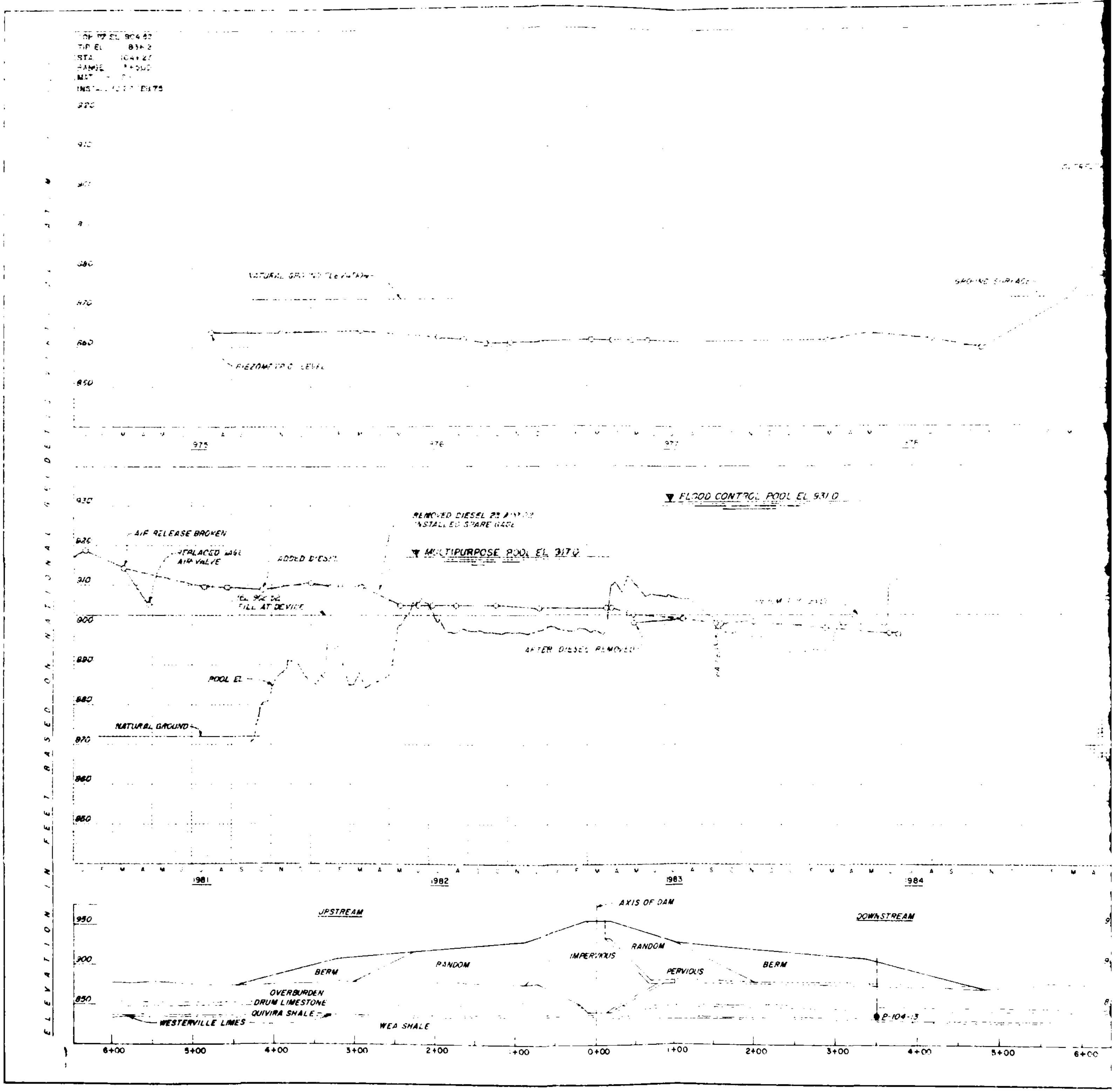
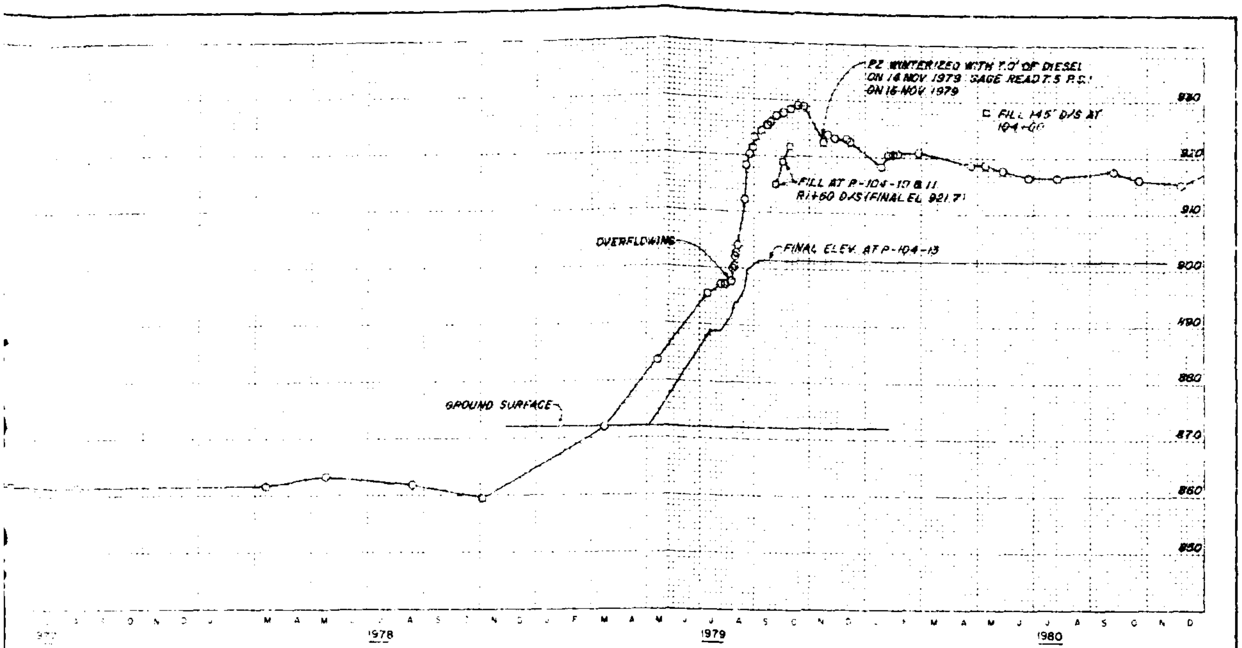
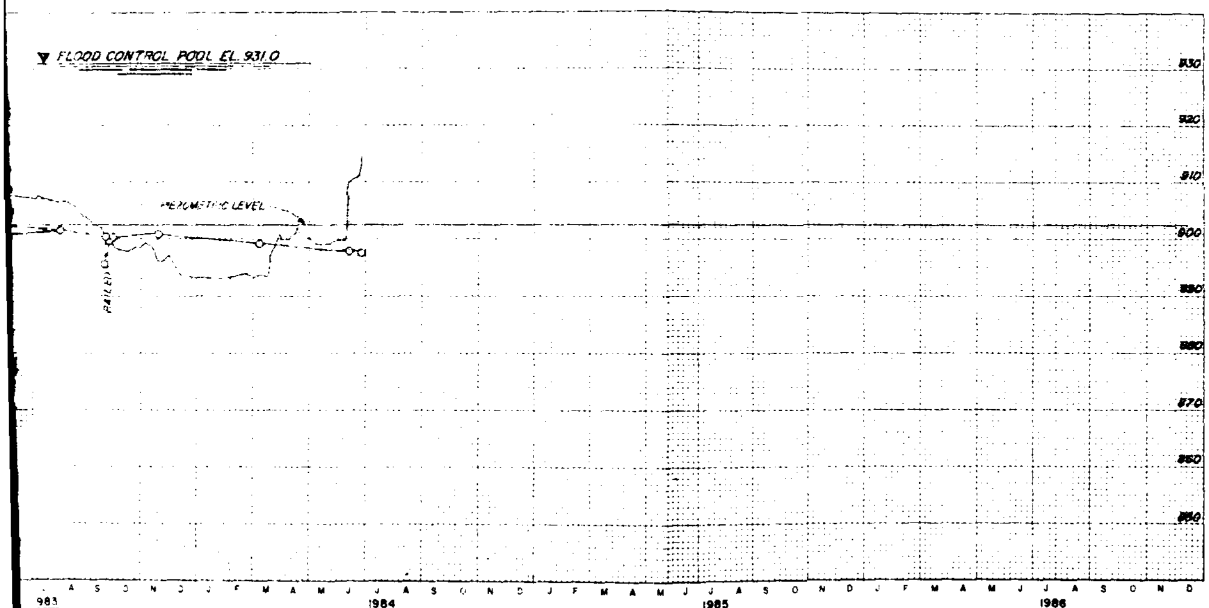
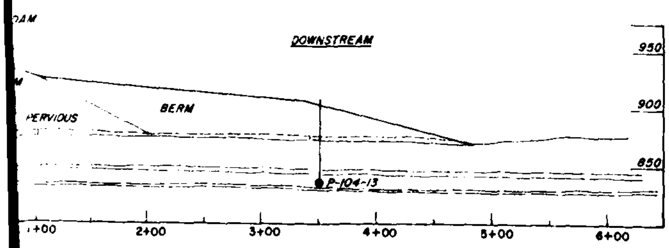
PLATE NO 248



NATURAL GROUND ELEVATION
GROUND SURFACE
PIEZOMETRIC LEVEL
FLOOD CONTROL POOL EL 931.0
MULTIPURPOSE POOL EL 917.0
REMOVED DIESEL 23 AUG 82
INSTALLED SPARE GAGE
AIR RELEASE BROKEN
REPLACED GAGE
AIR VALVE
ADDED DIESEL
FILL AT DEVICE
AFTER DIESEL REMOVED
POOL EL
NATURAL GROUND
1981
1982
1983
1984
AXIS OF DAM
UPSTREAM
DOWNSTREAM
RANDOM
IMPERVIOUS
BERM
PERVIOUS
OVERBURDEN
DRUM LIMESTONE
QUIVIRA SHALE
WESTERVILLE LIMES
WEA SHALE
P-104-13
ELEVATION IN FEET BASED ON NATIONAL GEODETIC







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OPEN TUBE PIEZOMETER
P-104-13

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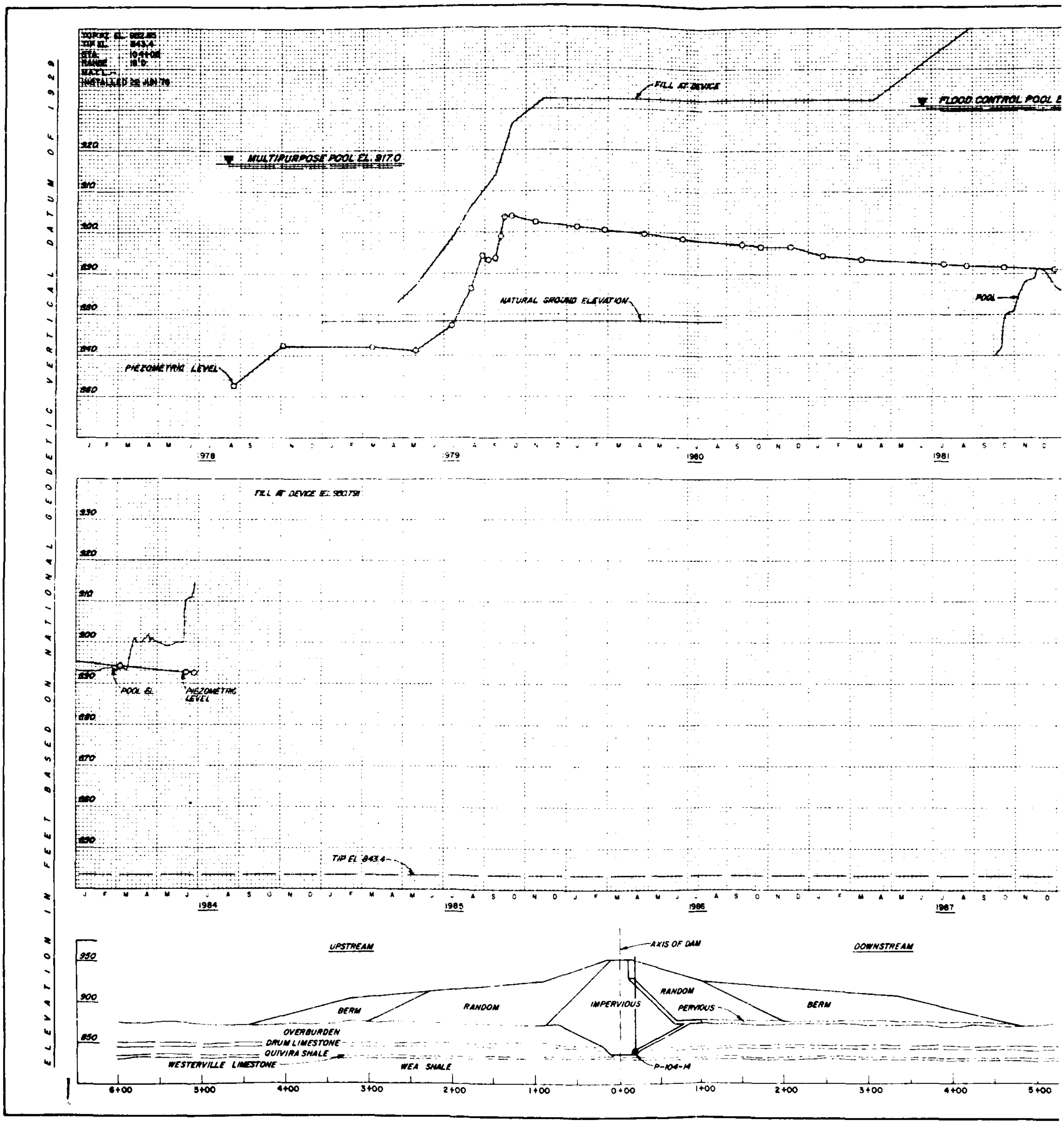
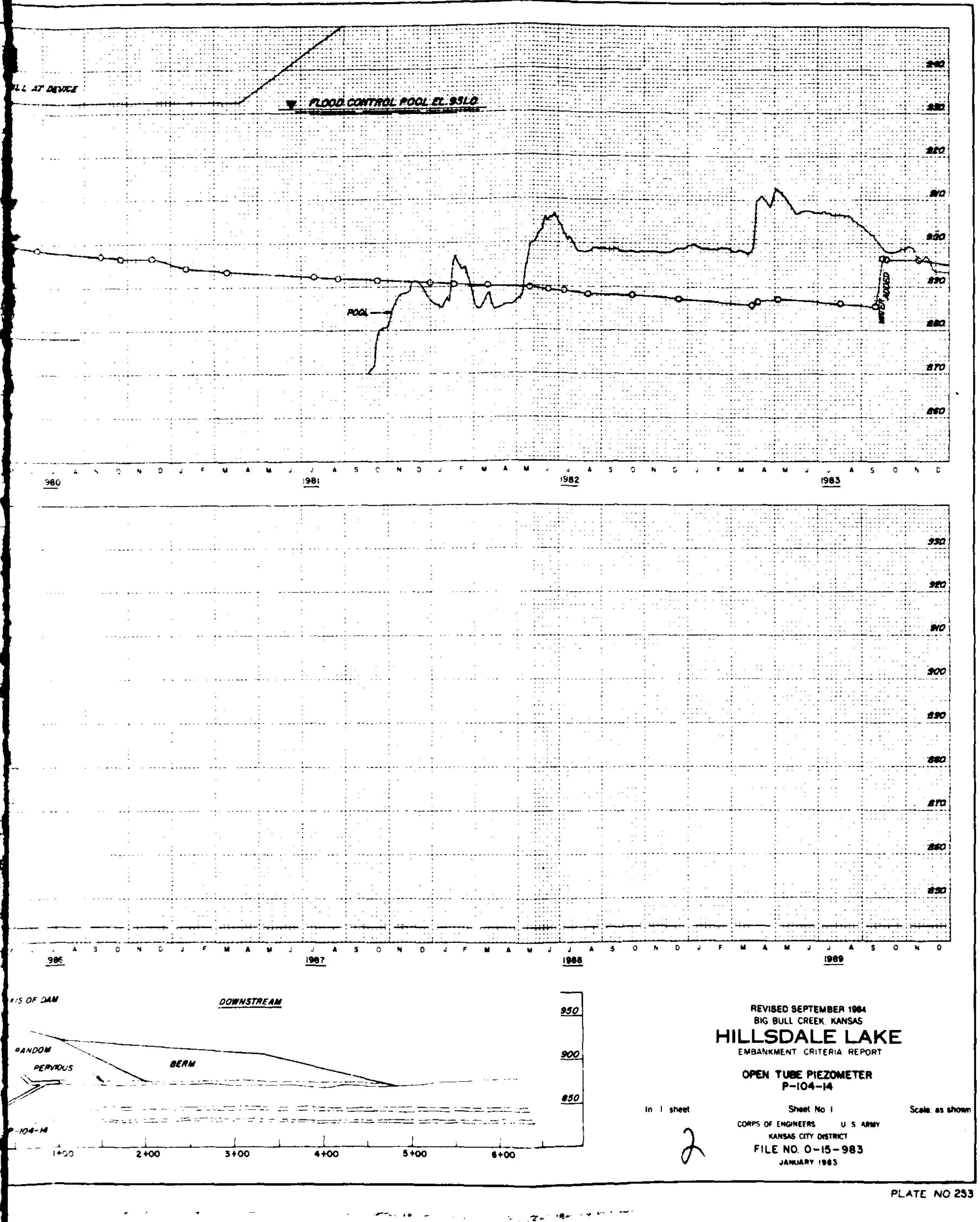
FILE NO. 0-15-982
JANUARY 1983

PLATE NO. 252


ELEVATION IN FEET BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929
FILL AT DEVICE
FLOOD CONTROL POOL
MULTIPURPOSE POOL EL. 917.0
NATURAL GROUND ELEVATION
PIEZOMETRIC LEVEL
POOL
1978
1979
1980
1981
FILL AT DEVICE
POOL EL
PIEZOMETRIC LEVEL
TIP EL 843.4
1984
1985
1986
1987
UPSTREAM
AXIS OF DAM
DOWNSTREAM
RANDOM
BERM
IMPERVIOUS
PERVIOUS
OVERBURDEN
DRUM LIMESTONE
QUIVIRA SHALE
WESTERVILLE LIMESTONE
WEA SHALE
P-104-14
950
900
850
6+00
5+00
4+00
3+00
2+00
1+00
0+00
1+00
2+00
3+00
4+00
5+00



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OPEN TUBE PIEZOMETER
P-104-14

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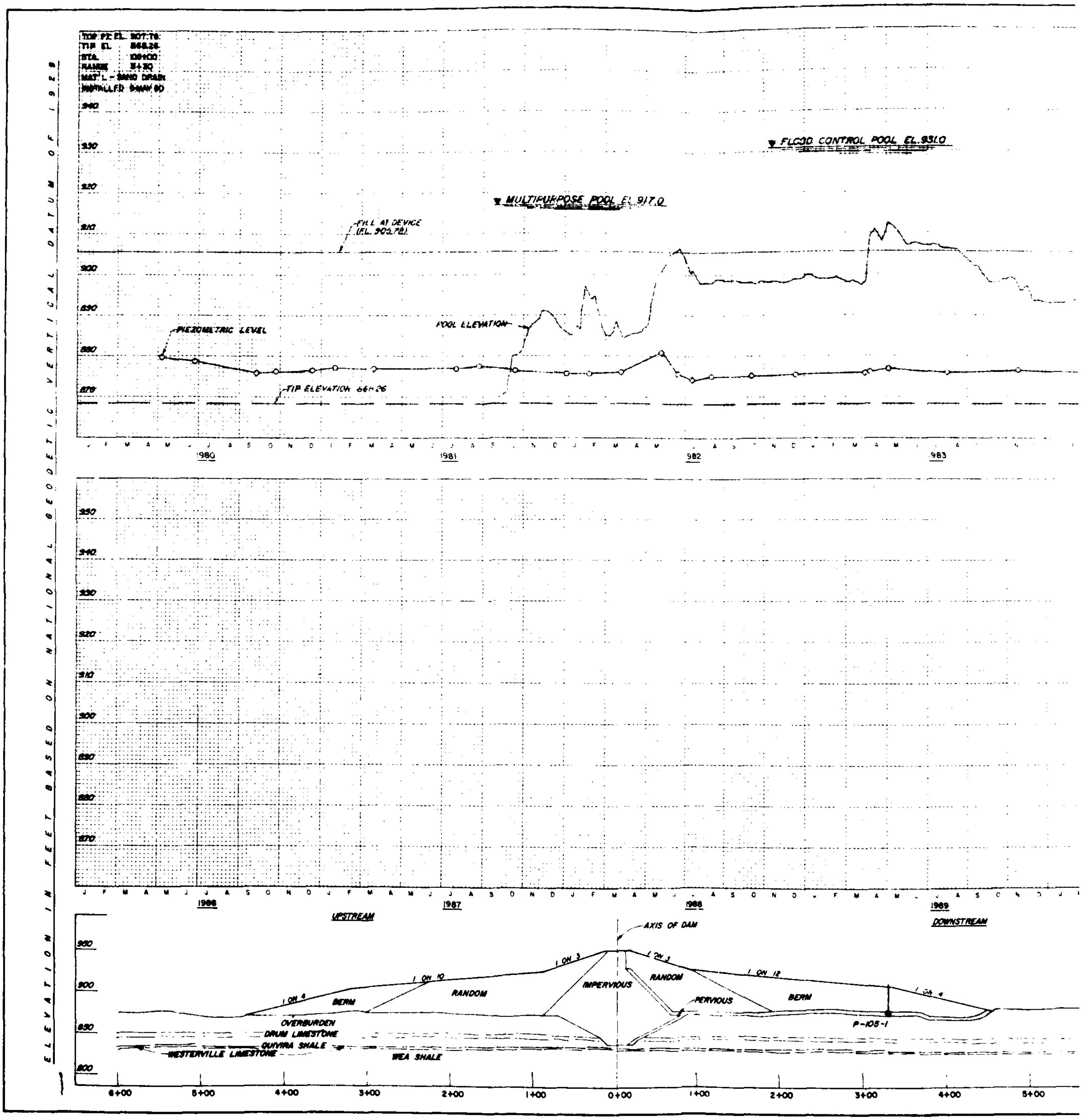
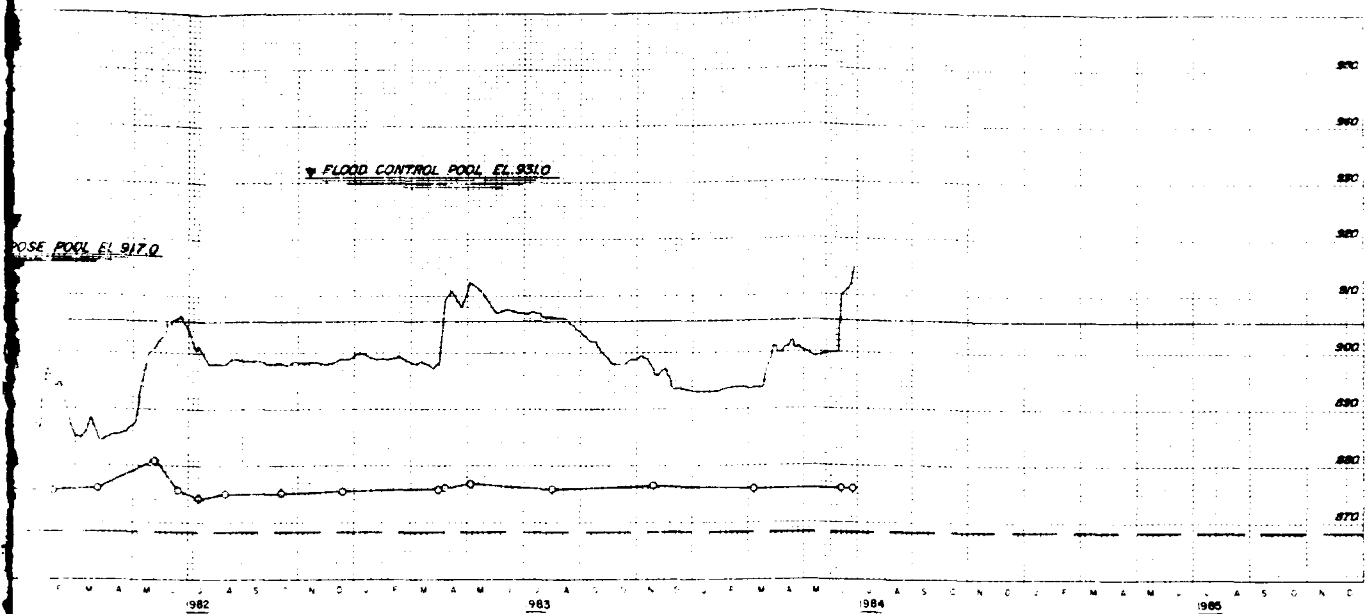
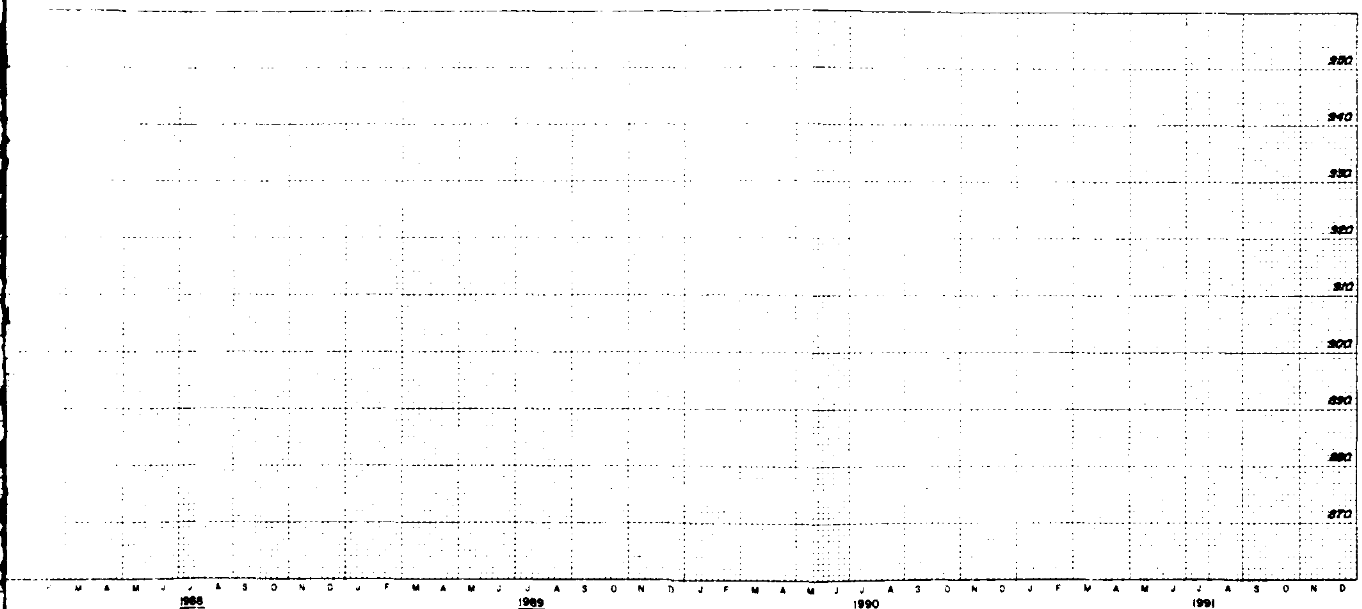
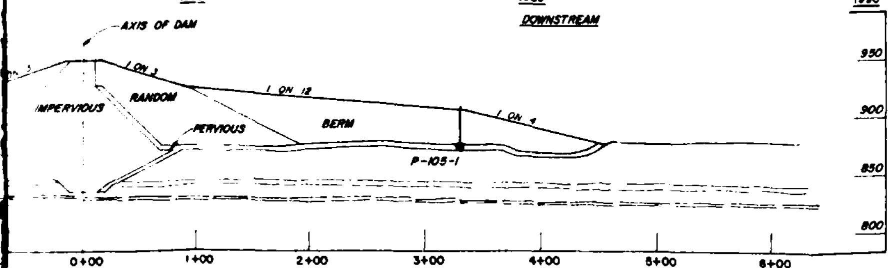
PLATE NO 253


ELEVATION IN FEET BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929
FLOOD CONTROL POOL EL. 931.0
MULTIPURPOSE POOL EL. 917.0
FILL AT DEVICE (EL. 905.78)
PIEZOMETRIC LEVEL
POOL ELEVATION
TIP ELEVATION
1980
1981
1982
1983
1986
1987
1988
1989
UPSTREAM
DOWNSTREAM
AXIS OF DAM
1 ON 4
1 ON 10
1 ON 3
1 ON 12
BERM
RANDOM
IMPERVIOUS
PERVIOUS
OVERBURDEN
DRUM LIMESTONE
QUIVIRA SHALE
WESTERVILLE LIMESTONE
WEA SHALE
P-105-1
6+00
5+00
4+00
3+00
2+00
1+00
0+00







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BIG BULL CREEK, KANSAS

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OPEN TUBE PIEZOMETER
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FILE NO. 0-15-984
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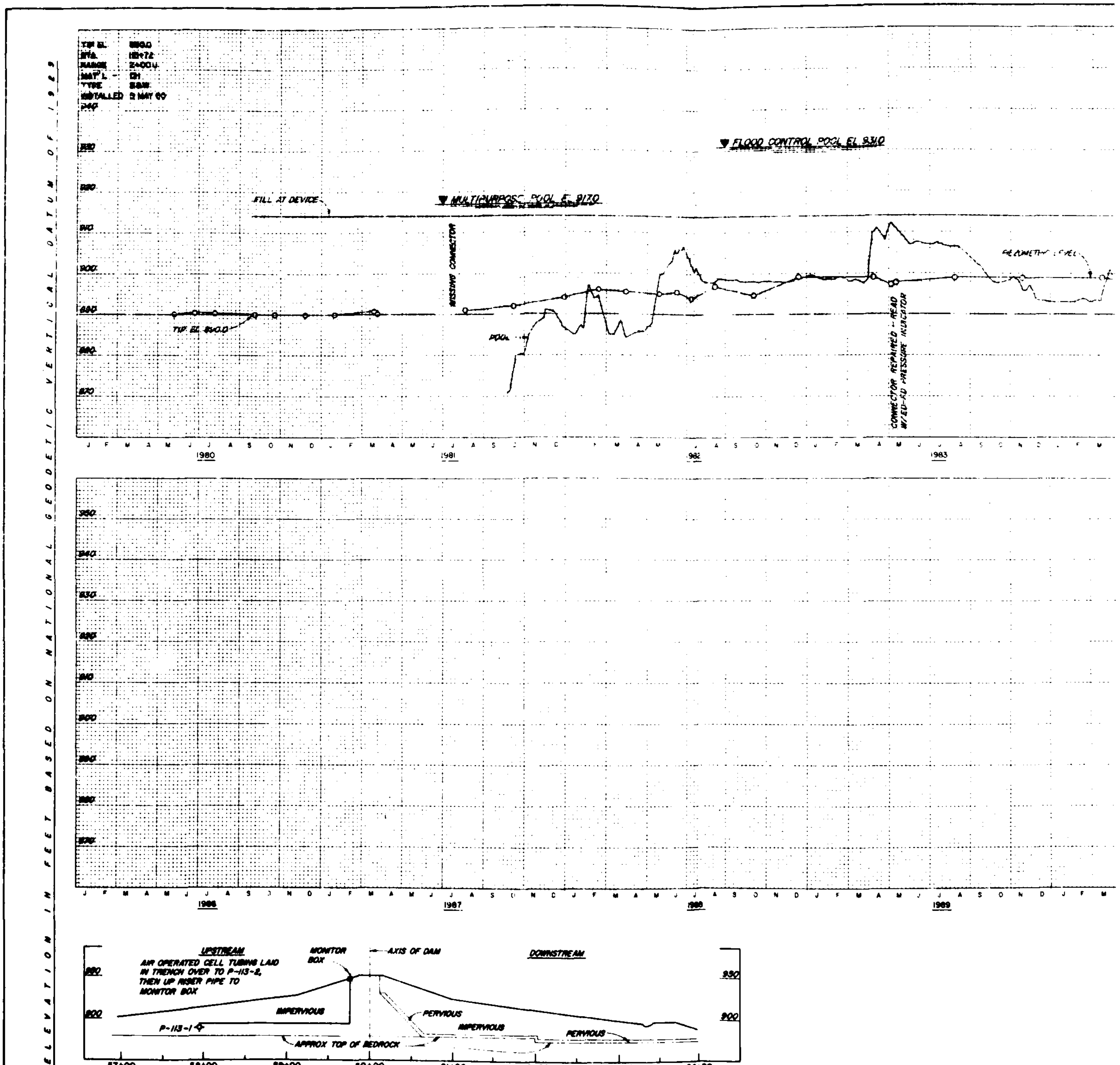
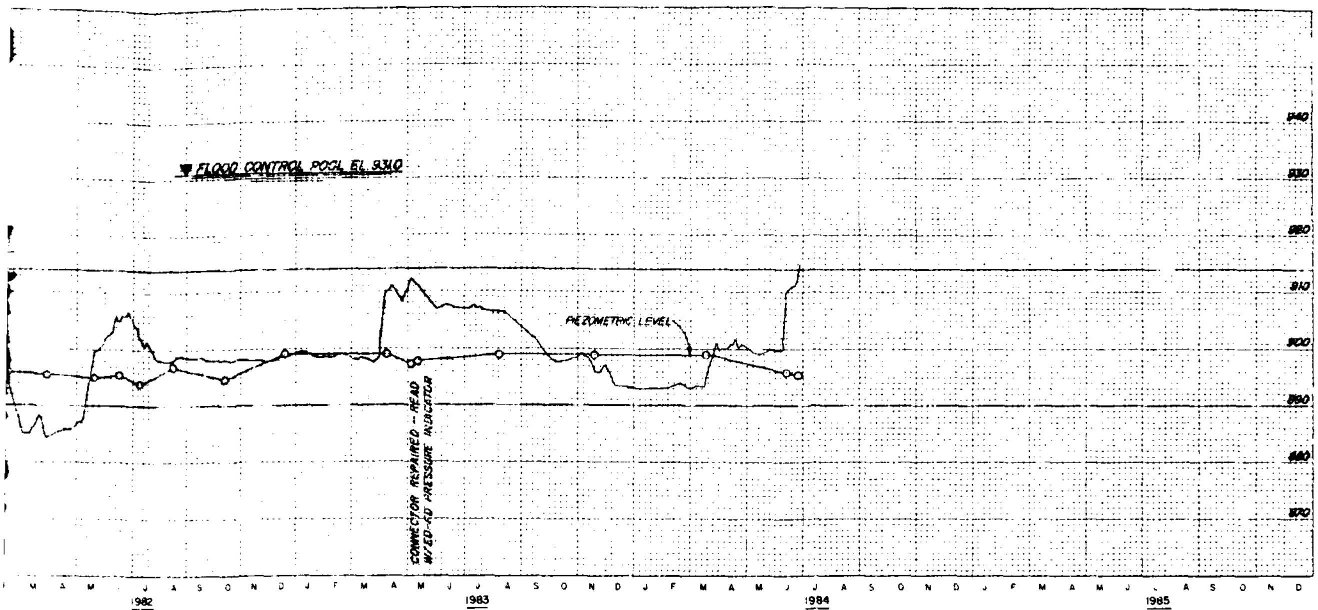
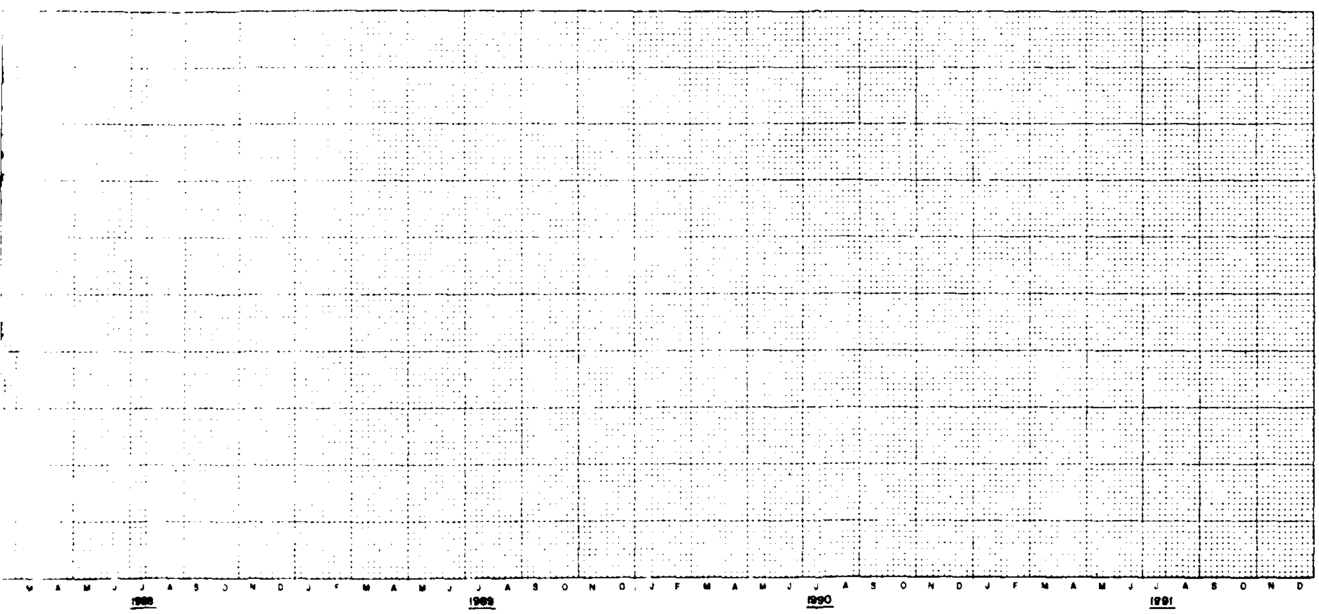
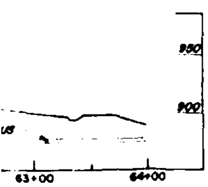
PLATE NO. 254



LONGITUDINAL SECTION PARALLEL TO OUTLET WORKS - 20' RT.







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EMBANKMENT CRITERIA REPORT

AIR CELL PIEZOMETER
P-113-1

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KANSAS CITY DISTRICT
FILE NO. 0-15-987
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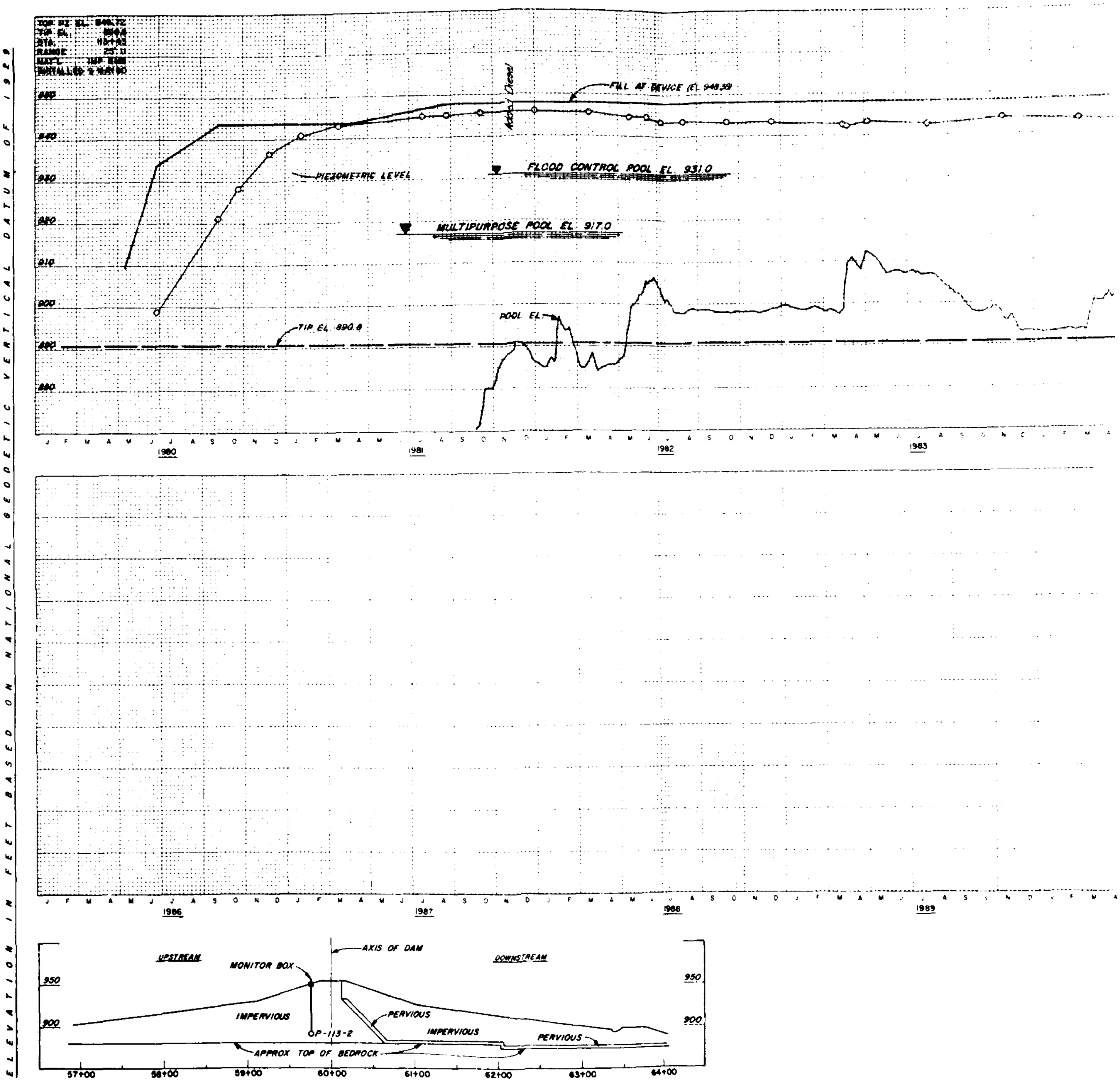
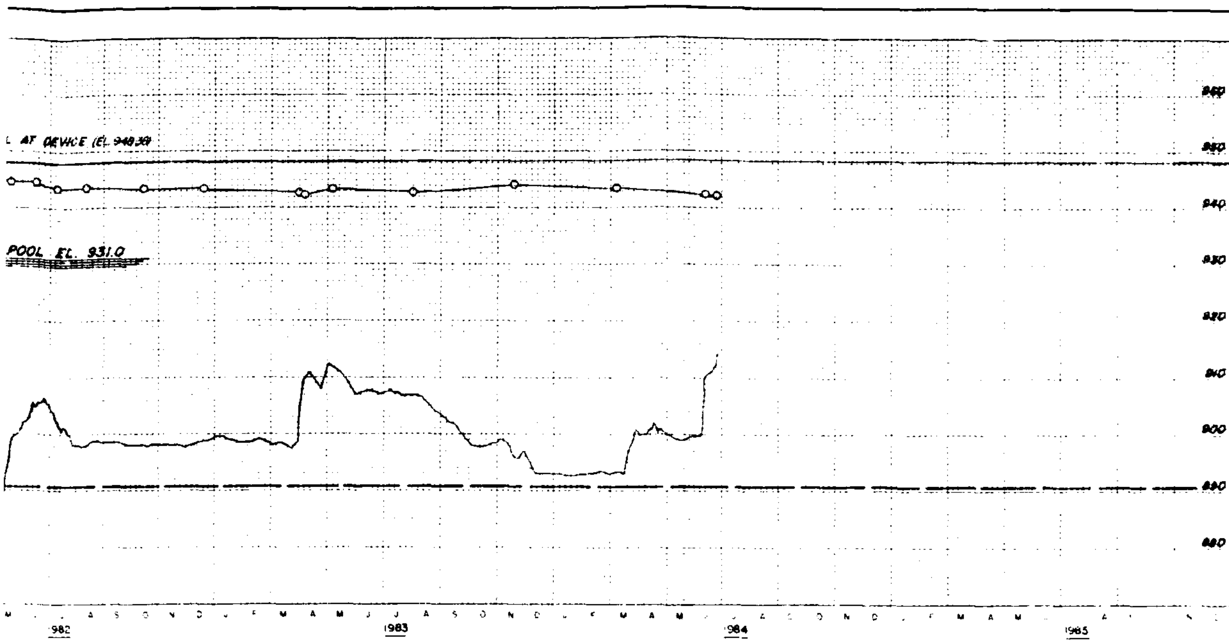
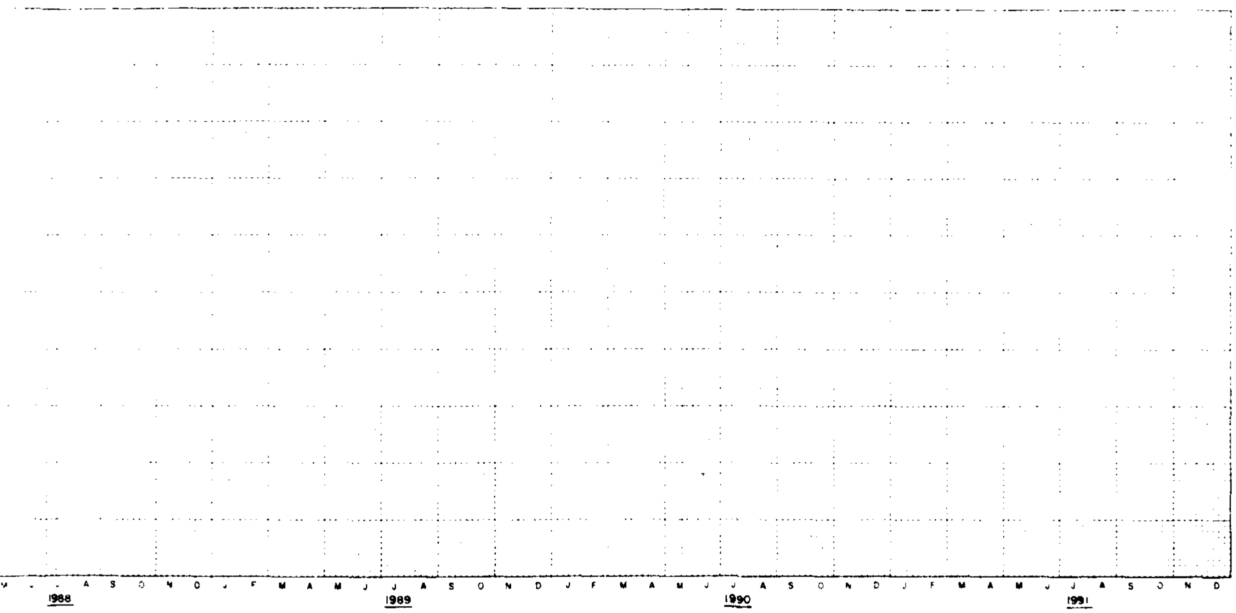
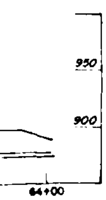
PLATE NO. 256



LONGITUDINAL SECTION PARALLEL TO OUTLET WORKS - 20' RT.







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EMBANKMENT CRITERIA REPORT

OPEN TUBE PIEZOMETER
P-113-2

In 1 sheet Sheet No 1 Scale: as shown

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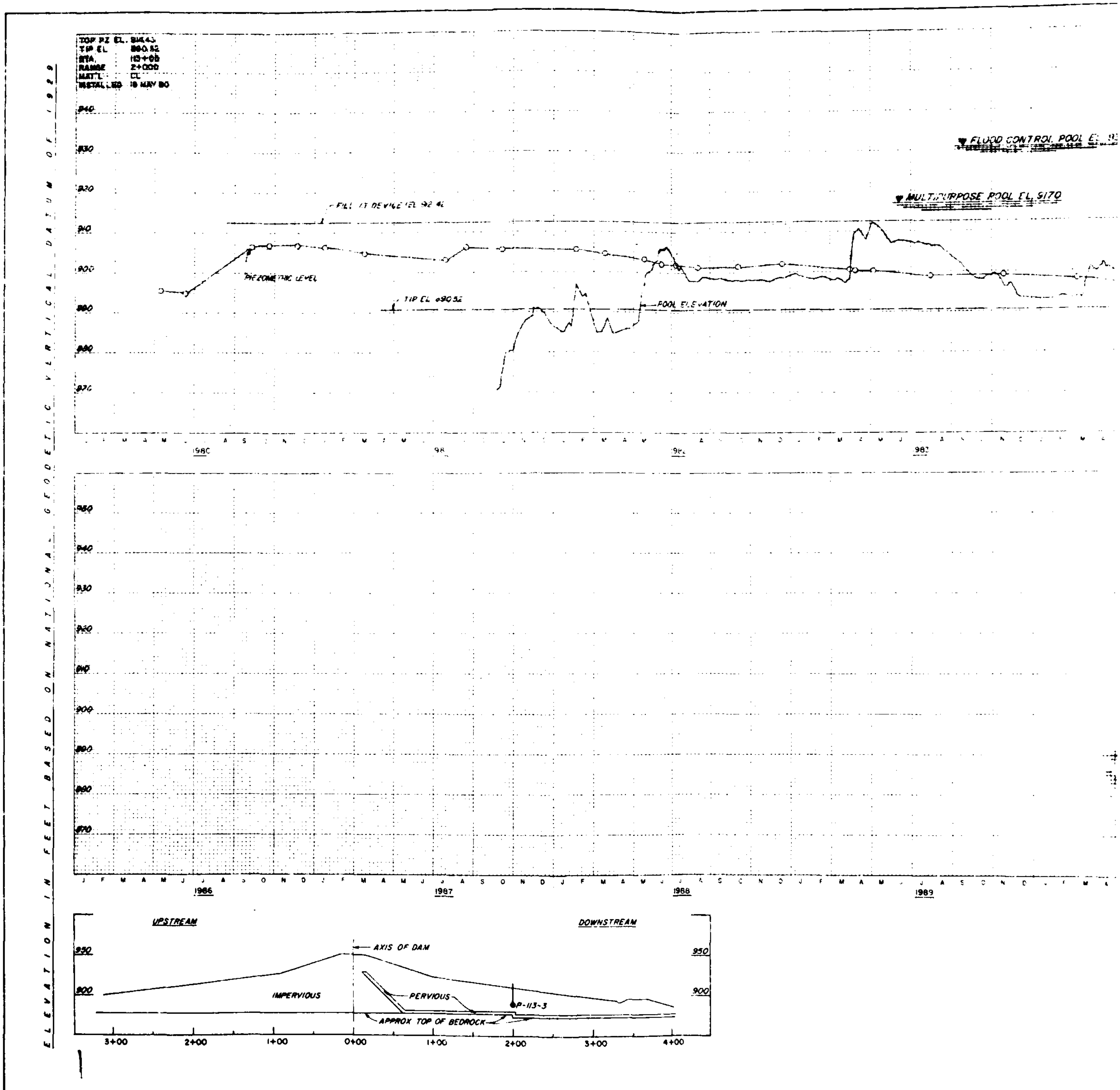
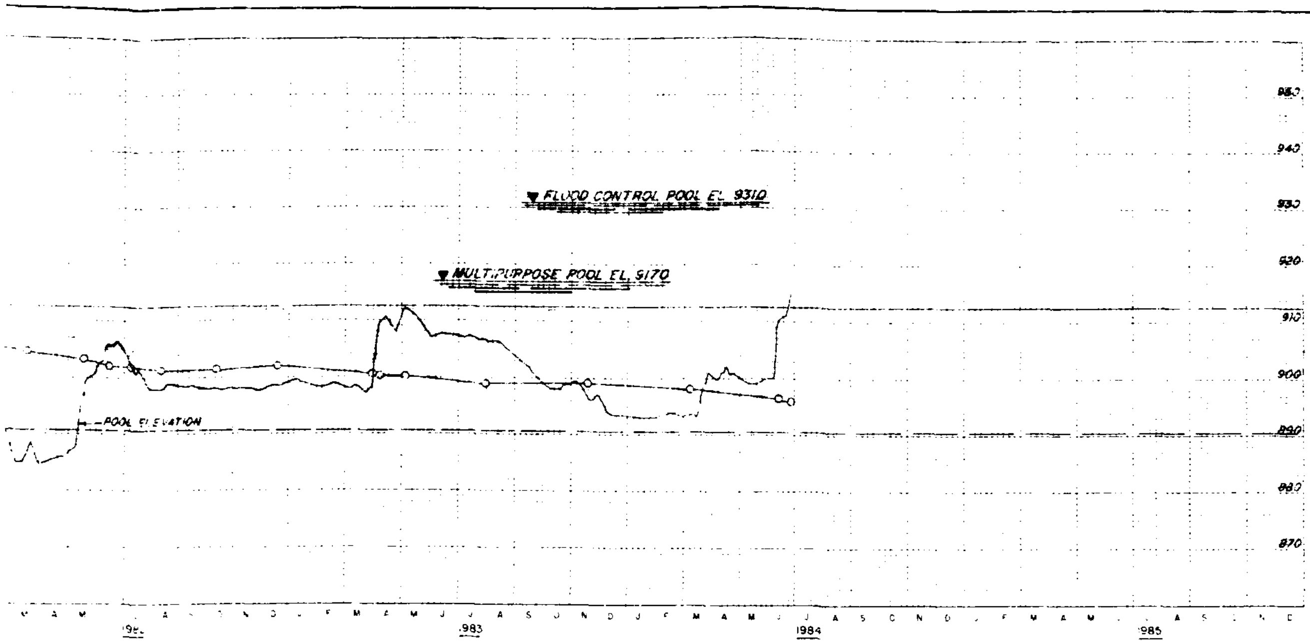
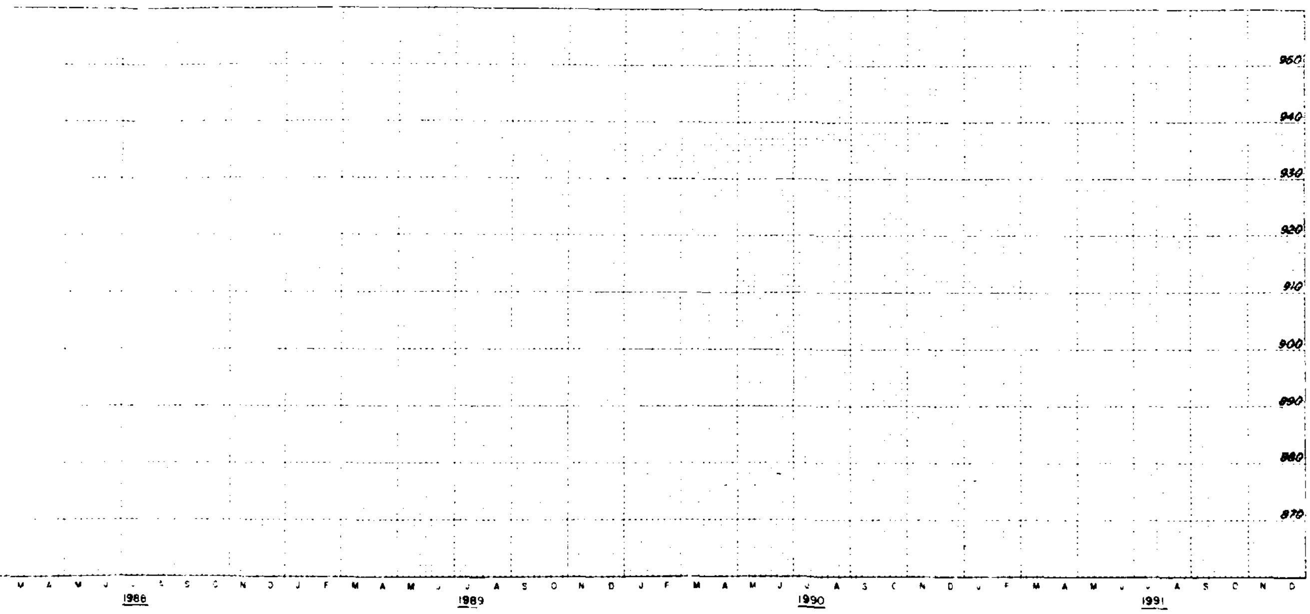
FILE NO. O-15-988
JANUARY 1983

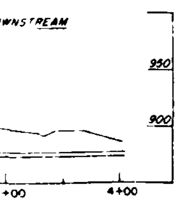
PLATE NO 257



ELEVATION IN FEET BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929
TOP PZ EL.
TIP EL
STA.
RANGE
MAT'L CL
INSTALLED
FLOOD CONTROL POOL EL
MULTIPURPOSE POOL EL
PIEZOMETRIC LEVEL
POOL ELEVATION
1986
1987
1988
1989
UPSTREAM
DOWNSTREAM
AXIS OF DAM
IMPERVIOUS
PERVIOUS
P-113-3
APPROX TOP OF BEDROCK







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OPEN TUBE PIEZOMETER
P-113-3

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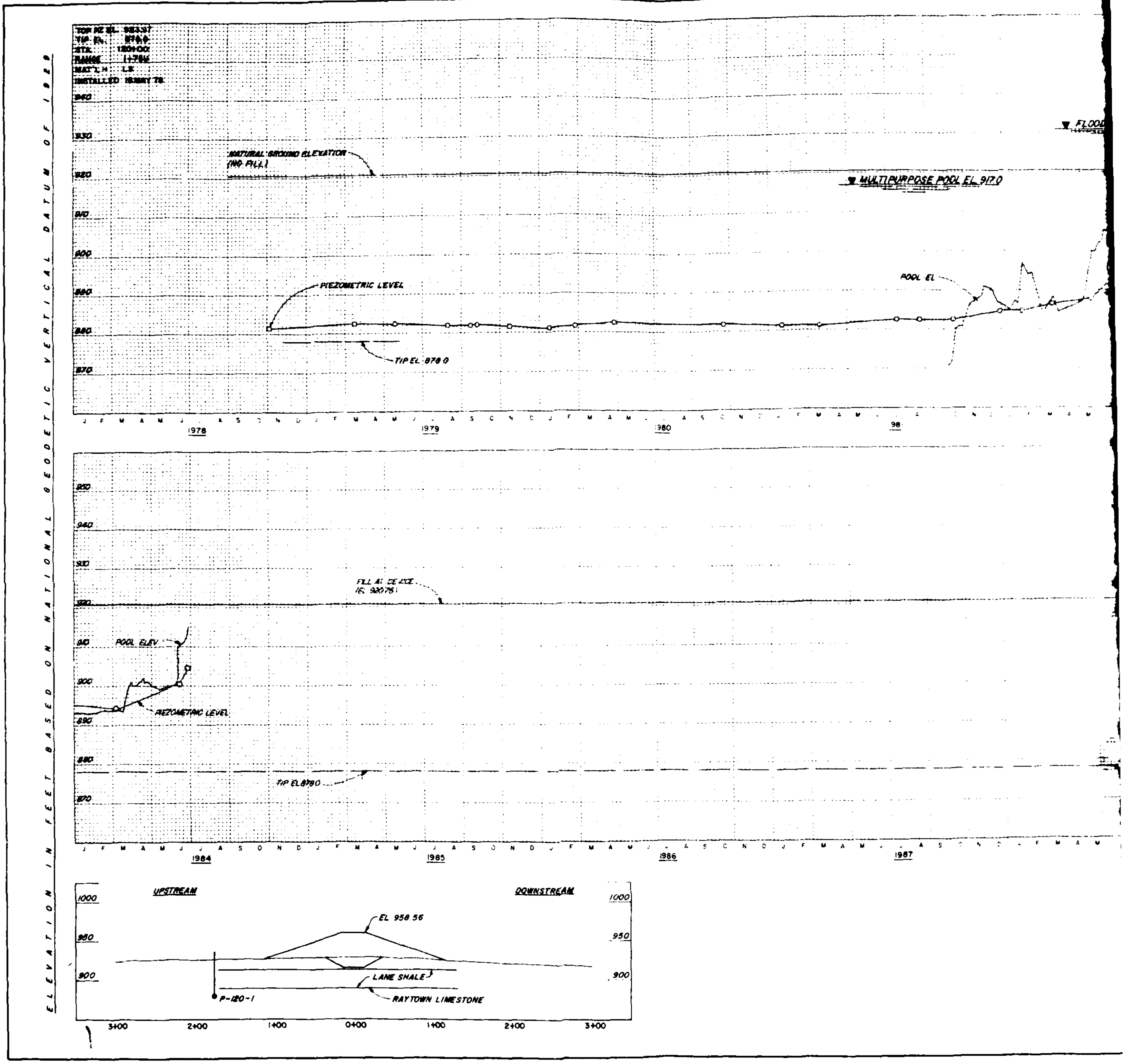
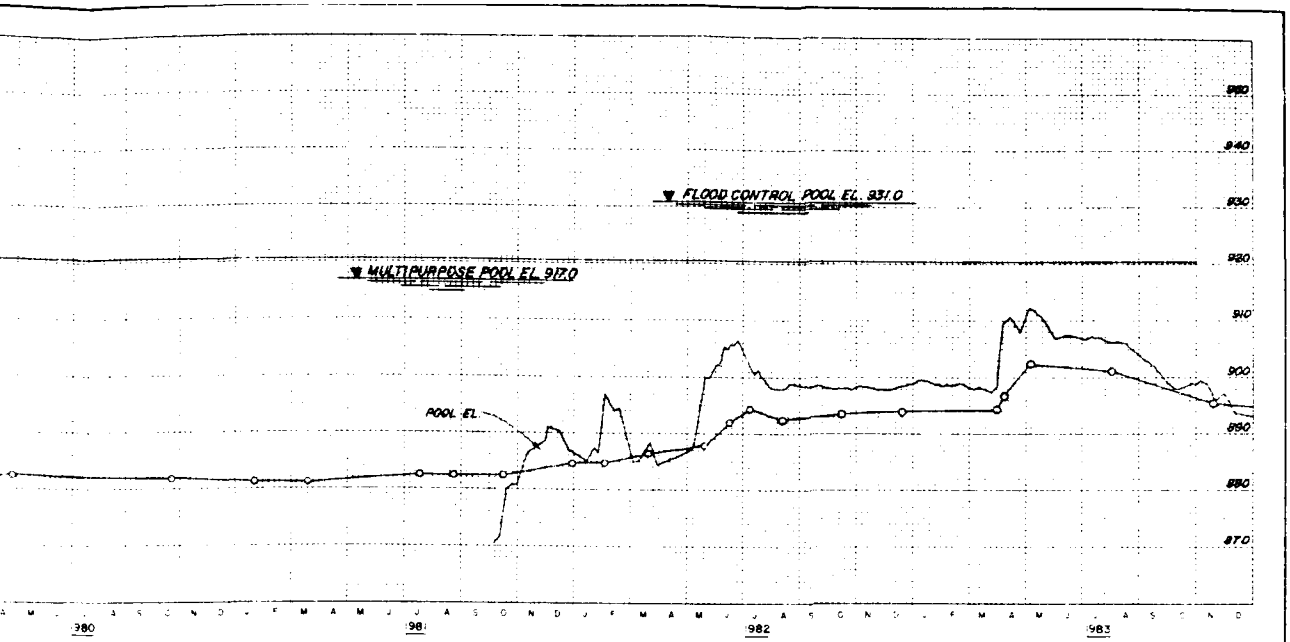
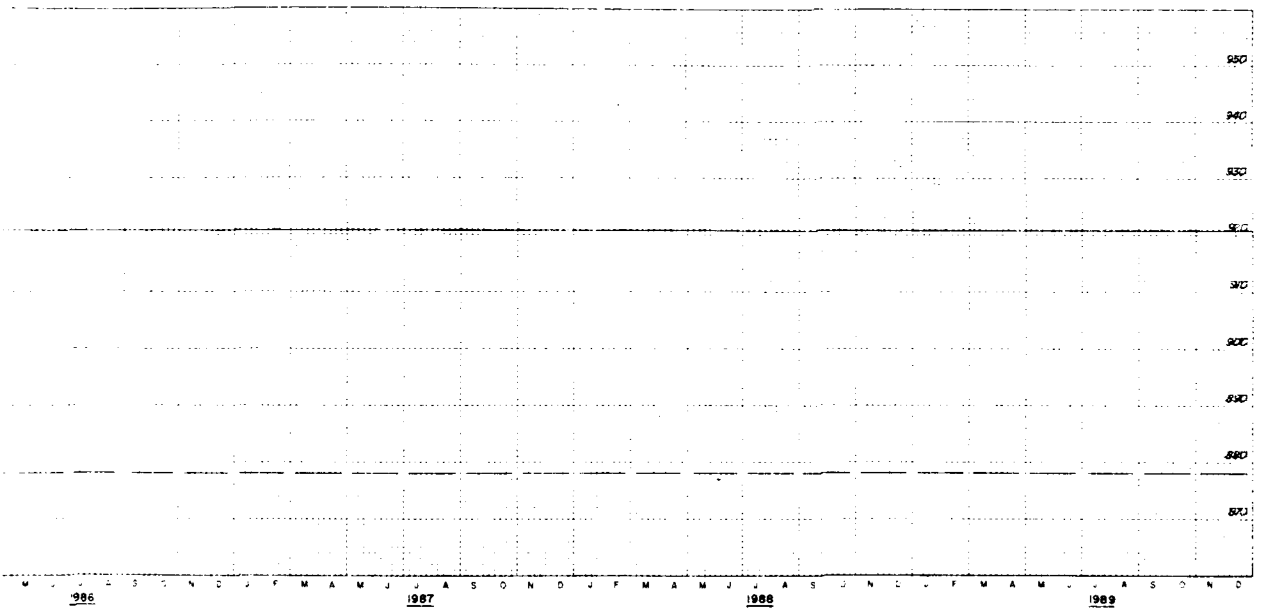

ELEVATION IN FEET BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929
STA. 120+00
NATURAL GROUND ELEVATION (NO FILL)
MULTIPURPOSE POOL EL 917.0
FLOOD
PIEZOMETRIC LEVEL
POOL EL
TIP EL 878.0
1978
1979
1980
FILL AT CE LINE (EL 920.75)
POOL ELEV
PIEZOMETRIC LEVEL
TIP EL 878.0
1984
1985
1986
1987
UPSTREAM
DOWNSTREAM
EL 958.56
LANE SHALE
RAYTOWN LIMESTONE
P-120-1
3+00
2+00
1+00
0+00
1+00
2+00
3+00





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OPEN TUBE PIEZOMETER
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FILE NO 0-15-990
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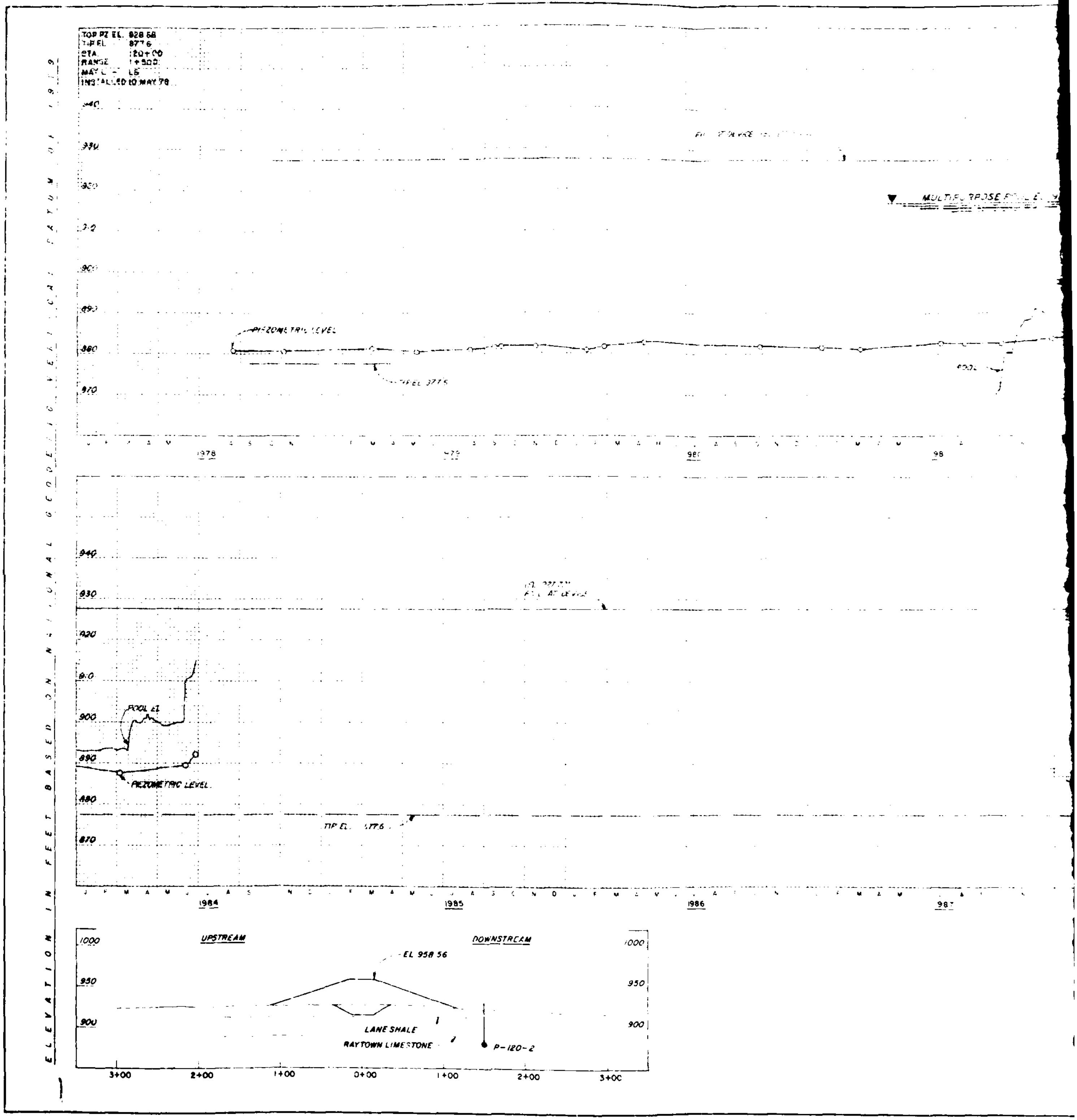
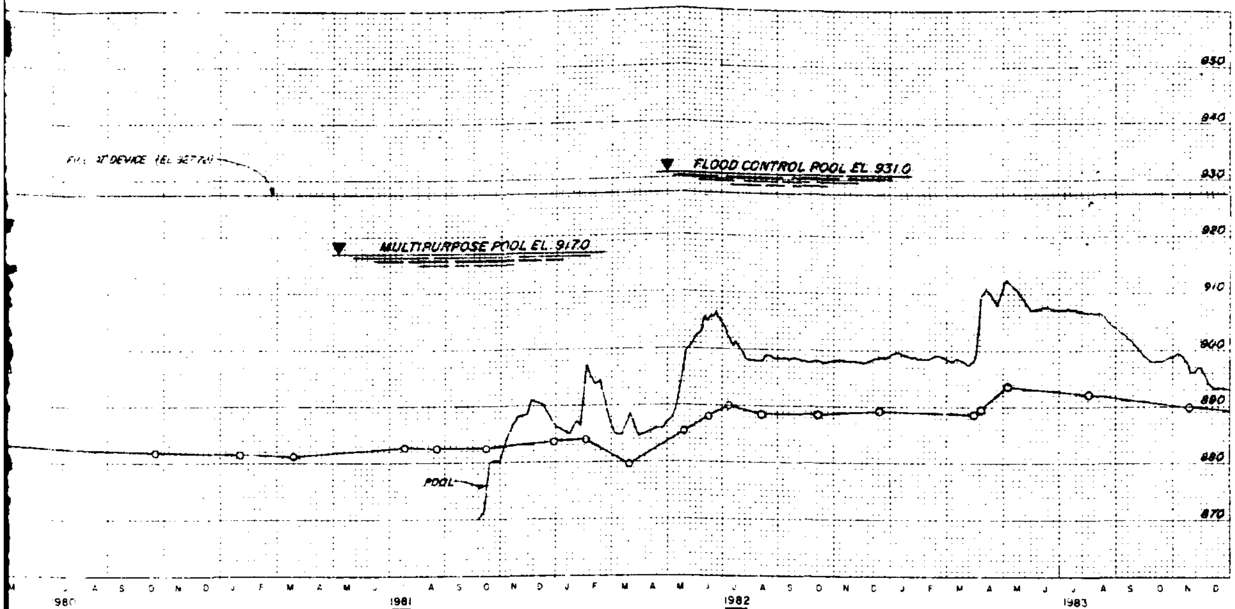
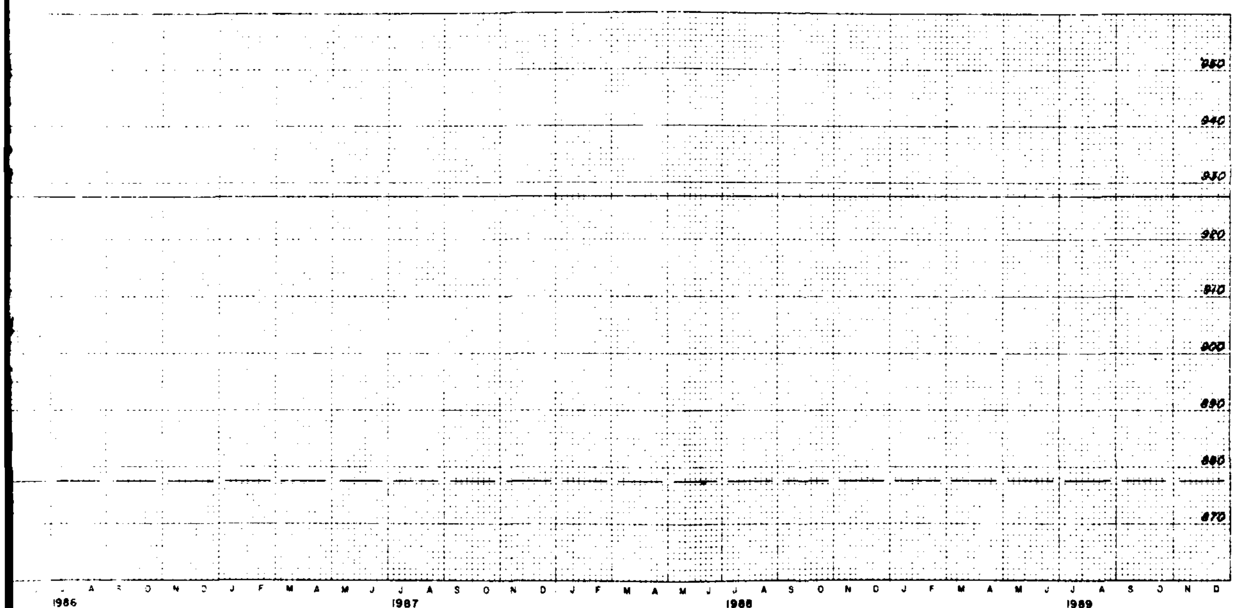
PLATE NO 259


TOP PZ EL. 928.58
TIP EL. 877.6
STA. 120+00
RANGE 1+500
INSTALLED 10 MAY 78
PIEZOMETRIC LEVEL
1978
1984
1985
1986
POOL EL
PIEZOMETRIC LEVEL
TIP EL. 877.6
UPSTREAM
DOWNSTREAM
EL 958.56
LANE SHALE
RAYTOWN LIMESTONE
P-120-2
ELEVATION IN FEET BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929





REVISED SEPTEMBER 1984
BIG BULL CREEK, KANSAS

HILLSDALE LAKE

EMBANKMENT CRITERIA REPORT

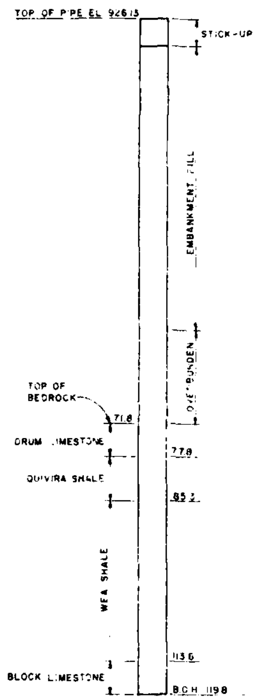
OPEN TUBE PIEZOMETER
P-120-2

In 1 sheet | Sheet No. 1 | Scale: as shown

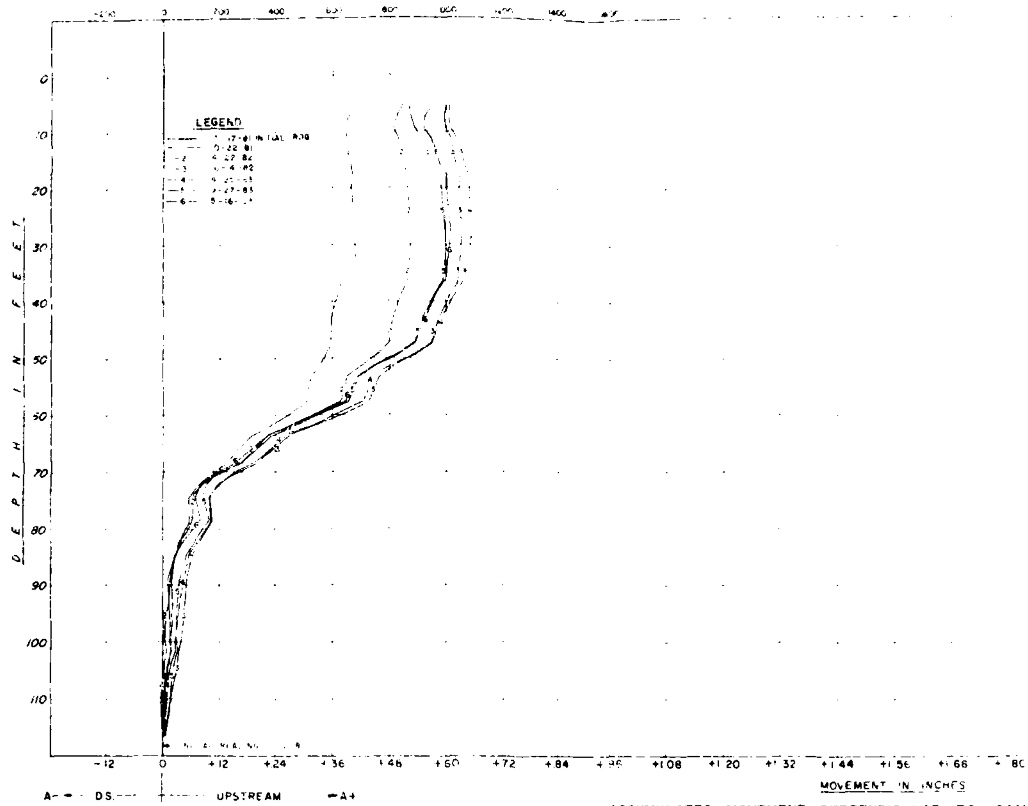
CORPS OF ENGINEERS U. S. ARMY
KANSAS CITY DISTRICT
FILE NO. 0-15-996
JANUARY 1983

2

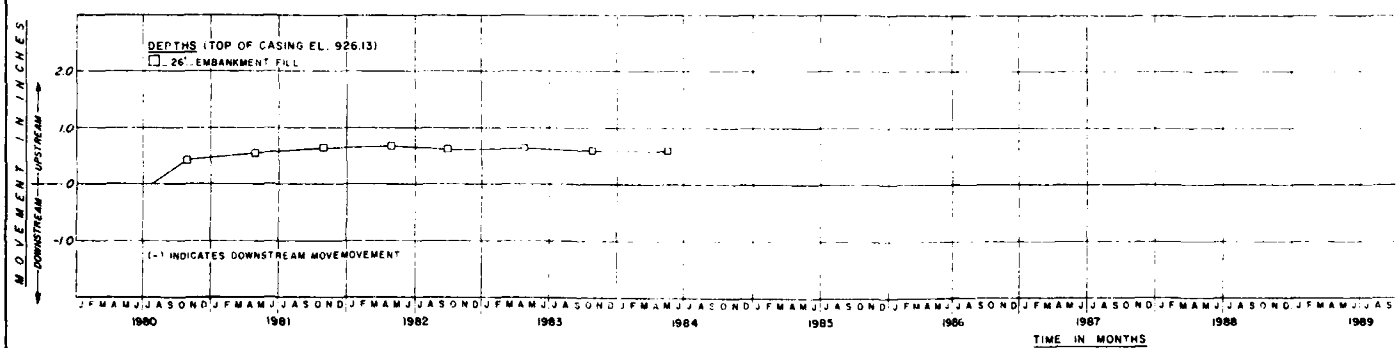
PLATE NO 260



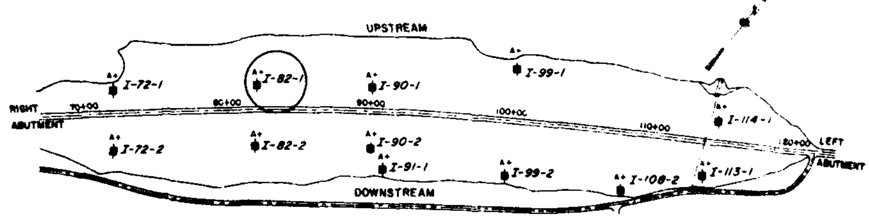
I-82-1
STATION 82+00
RANGE 1+40 U/S
INSTALLED 6-5-81

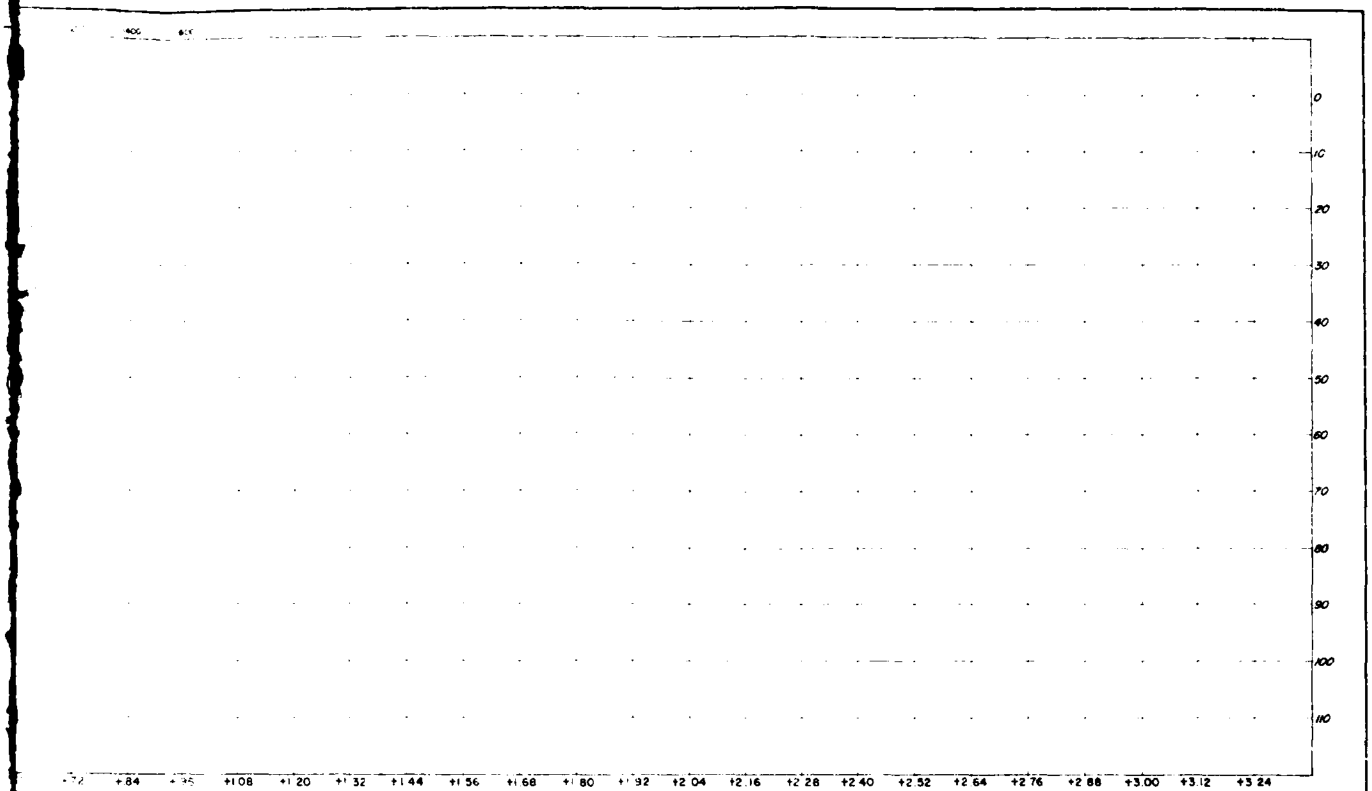


ACCUMULATED MOVEMENT PERPENDICULAR TO DAM

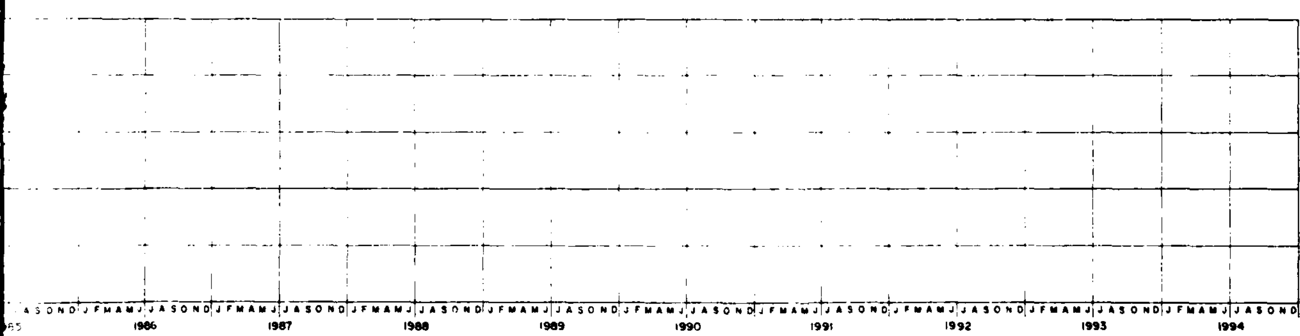


TIME VS. MOVEMENT

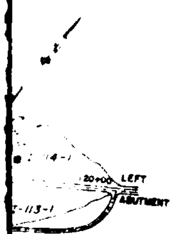




ACCUMULATED MOVEMENT PERPENDICULAR TO DAM AXIS VS. DEPTH



TIME VS. MOVEMENT



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BIG BULL CREEK, KANSAS

HILLSDALE LAKE

EMBANKMENT CRITERIA REPORT

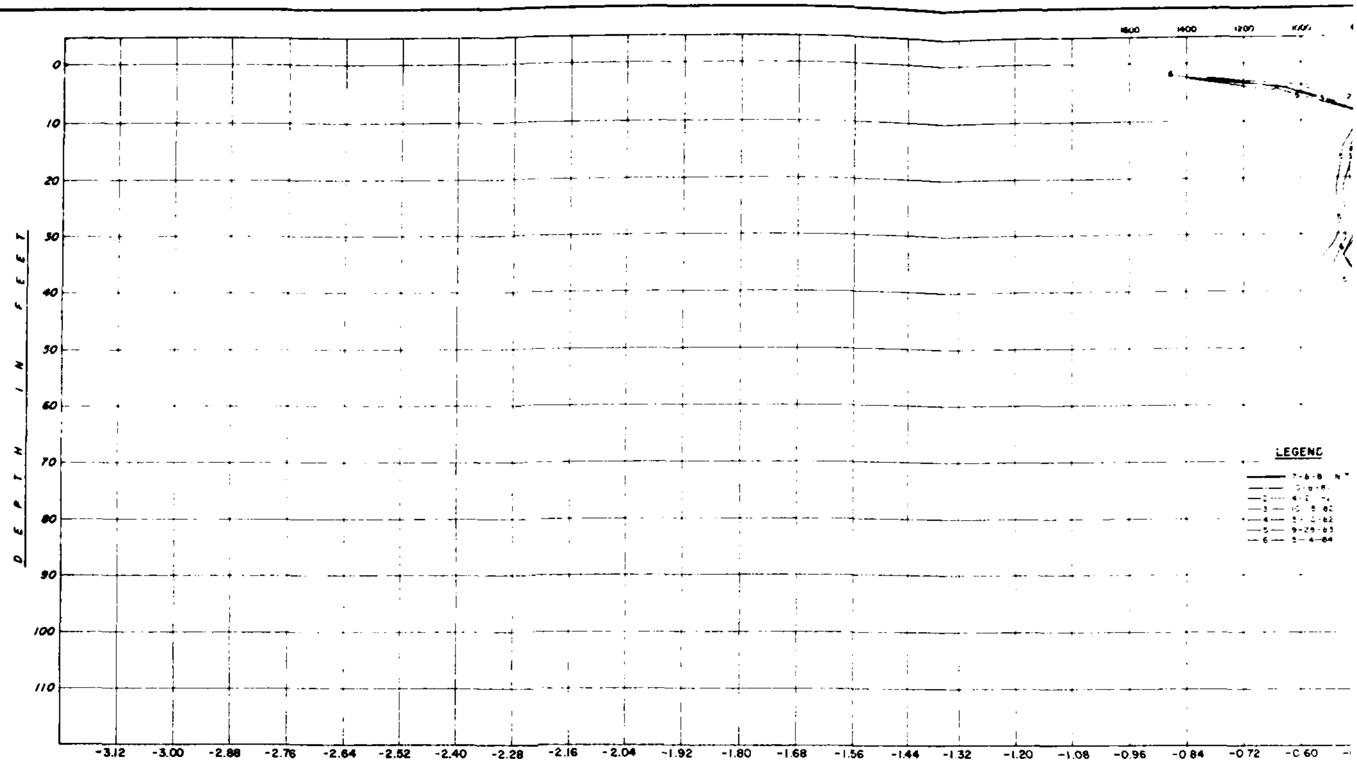
INCLINOMETER
I-82-1

in 1 sheet | Sheet No. 1 | Scale: as shown

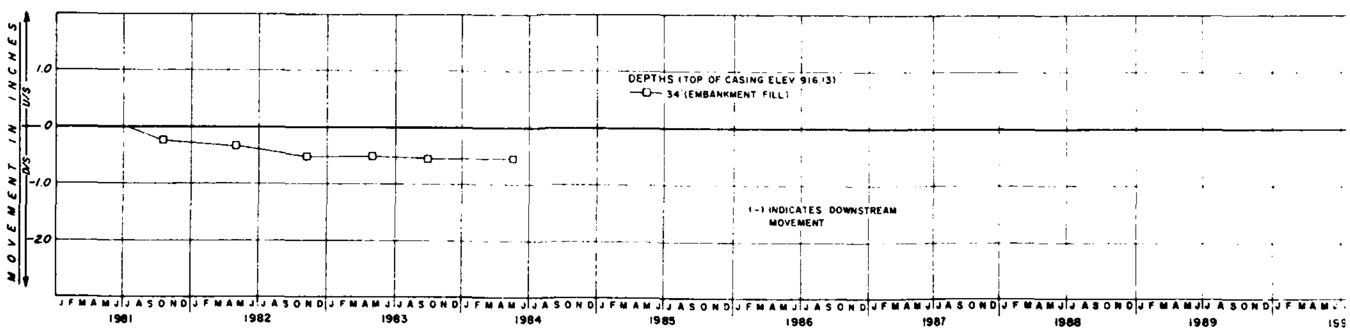
CORPS OF ENGINEERS U. S. ARMY
KANSAS CITY DISTRICT
FILE NO. 0-15-1046
JANUARY 1984

2

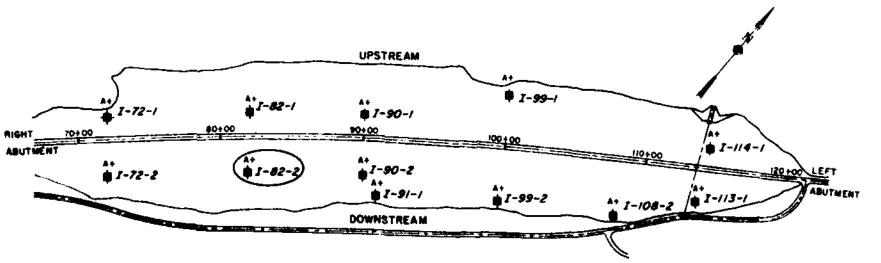
PLATE NO. 263

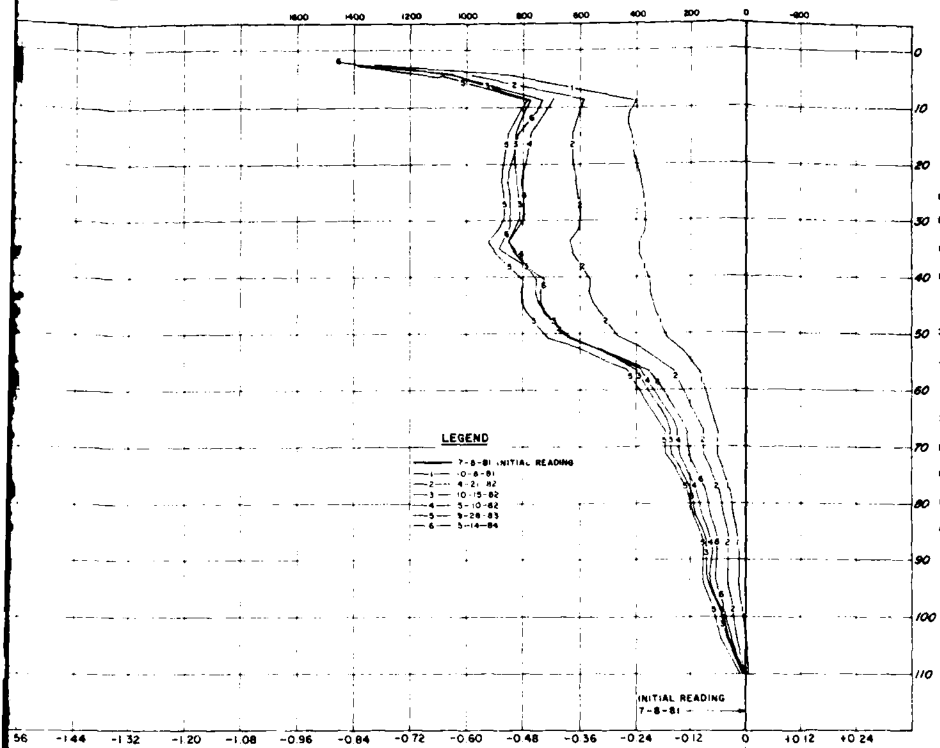


ACCUMULATED MOVEMENT PERPENDICULAR TO DAM AXIS VS. DEPTH



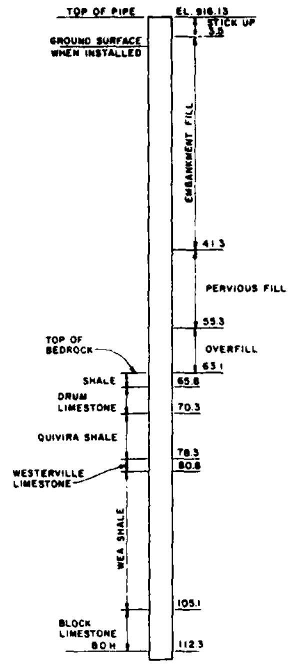
TIME VS. MOVEMENT



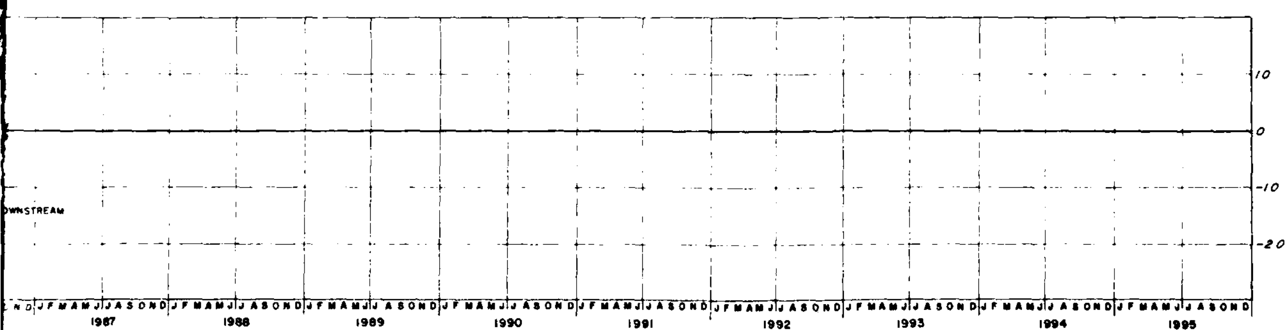


MOVEMENT IN INCHES

ERPENDICULAR TO DAM AXIS VS. DEPTH

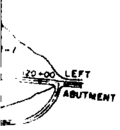


I-82-2
STA. 82+00
RANGE 2+50 D/S
INSTALLED 6-3-81



TIME IN MONTHS

TIME VS. MOVEMENT



REVISED SEPTEMBER 1984
BIG BULL CREEK, KANSAS

HILLSDALE LAKE

EMBANKMENT CRITERIA REPORT

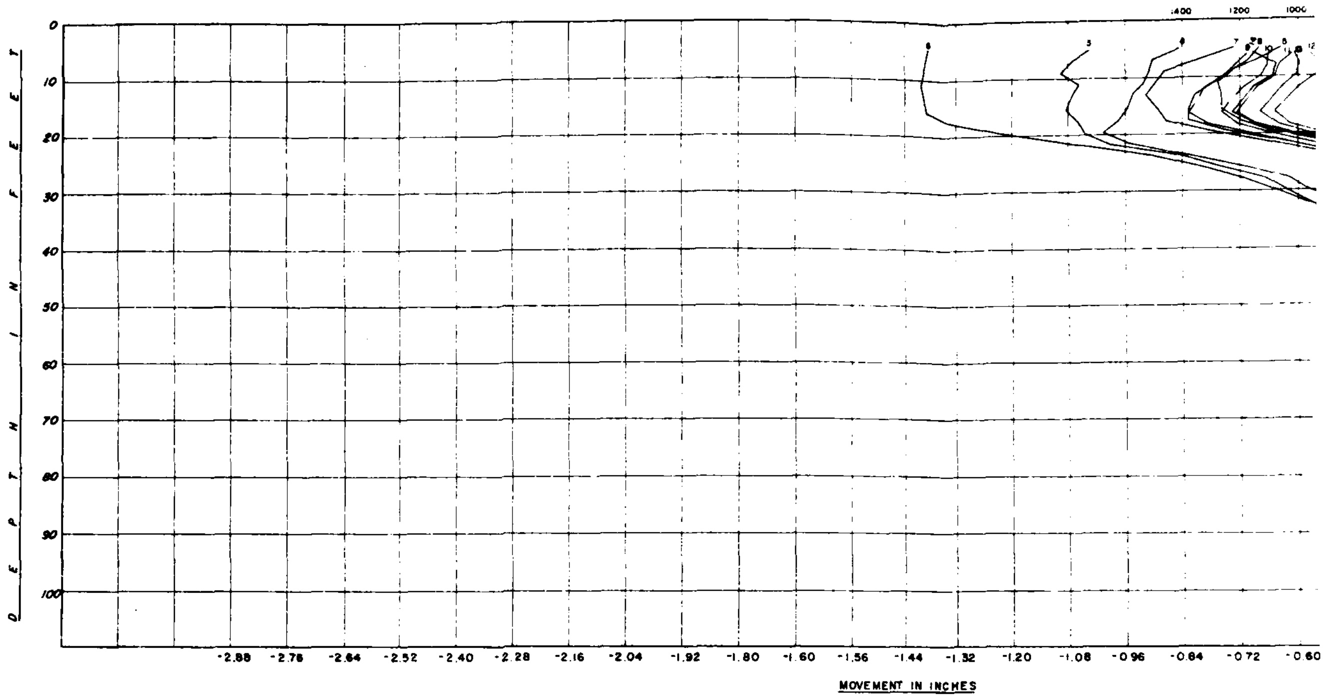
INCLINOMETER
I-82-2

In 1 sheet | Sheet No. 1 | Scale: as shown

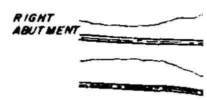
CORPS OF ENGINEERS U. S. ARMY
KANSAS CITY DISTRICT
FILE NO. 0-15-1047
JANUARY 1984

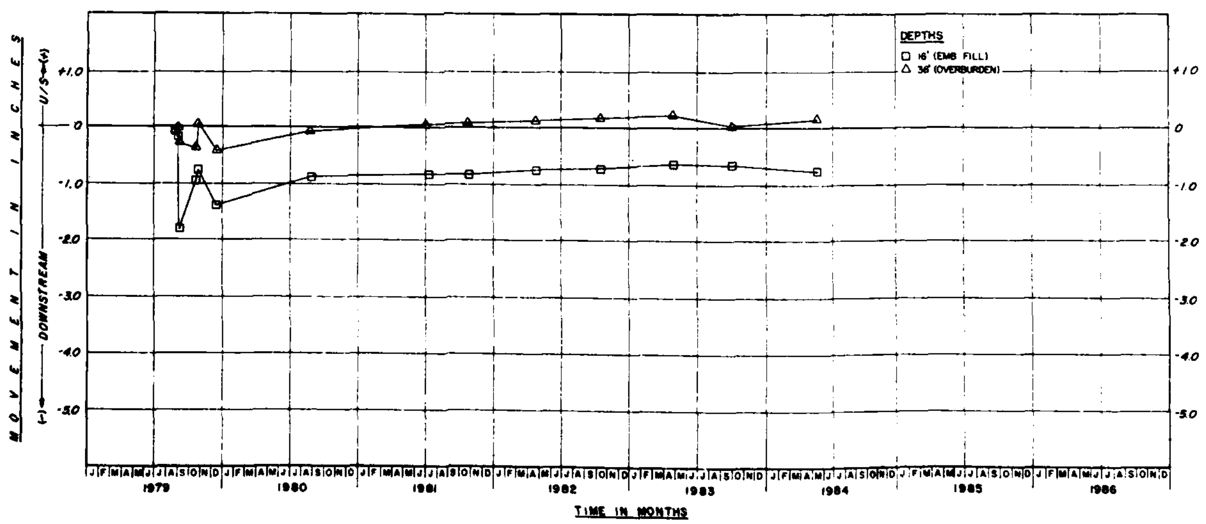
2

PLATE NO 264



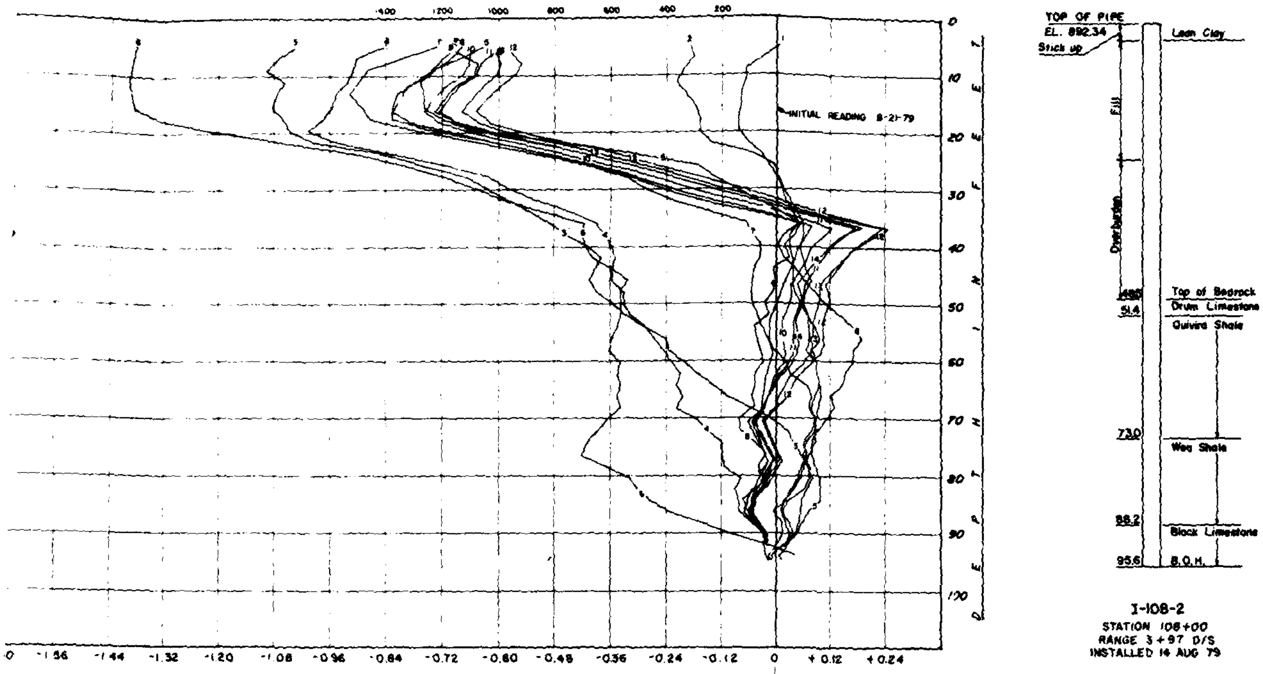
ACCUMULATED MOVEMENT P??ENDICULAR TO DAM AXIS VS. DEPTH





MOVEMENT VS. TIME

(-) INDICATES DOWNSTREAM MOVEMENT

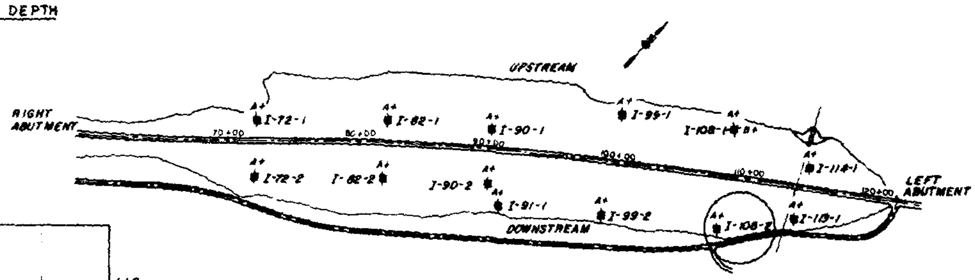


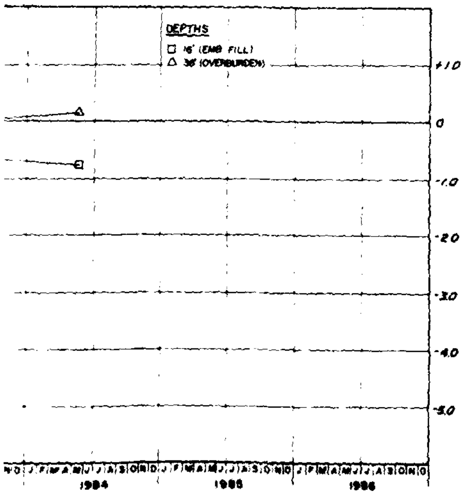
I-108-2
STATION 108+00
RANGE 3+97 D/S
INSTALLED 14 AUG 79

MOVEMENT IN INCHES

A- ——DOWNSTREAM—— ——UPSTREAM—— A+

ENT PERPENDICULAR TO DAM AXIS VS. DEPTH





LEGEND

——	21 AUG 79 (INITIAL READING)
—1—	23 AUG 79
—2—	30 AUG 79
—3—	15 SEP 79
—4—	17 OCT 79
—5—	26 OCT 79
—6—	13 DEC 79
—7—	19 AUG 80
—8—	8 JUL 81
—9—	22 OCT 81 (FIRST READING WITH DIGITILT)
—10—	20 APR 82
—11—	13 OCT 82
—12—	27 APR 83
—13—	22 SEP 83
—14—	15 MAY 84

REVISED SEPTEMBER 1984
BIG BULL CREEK, KANSAS

HILLSDALE LAKE

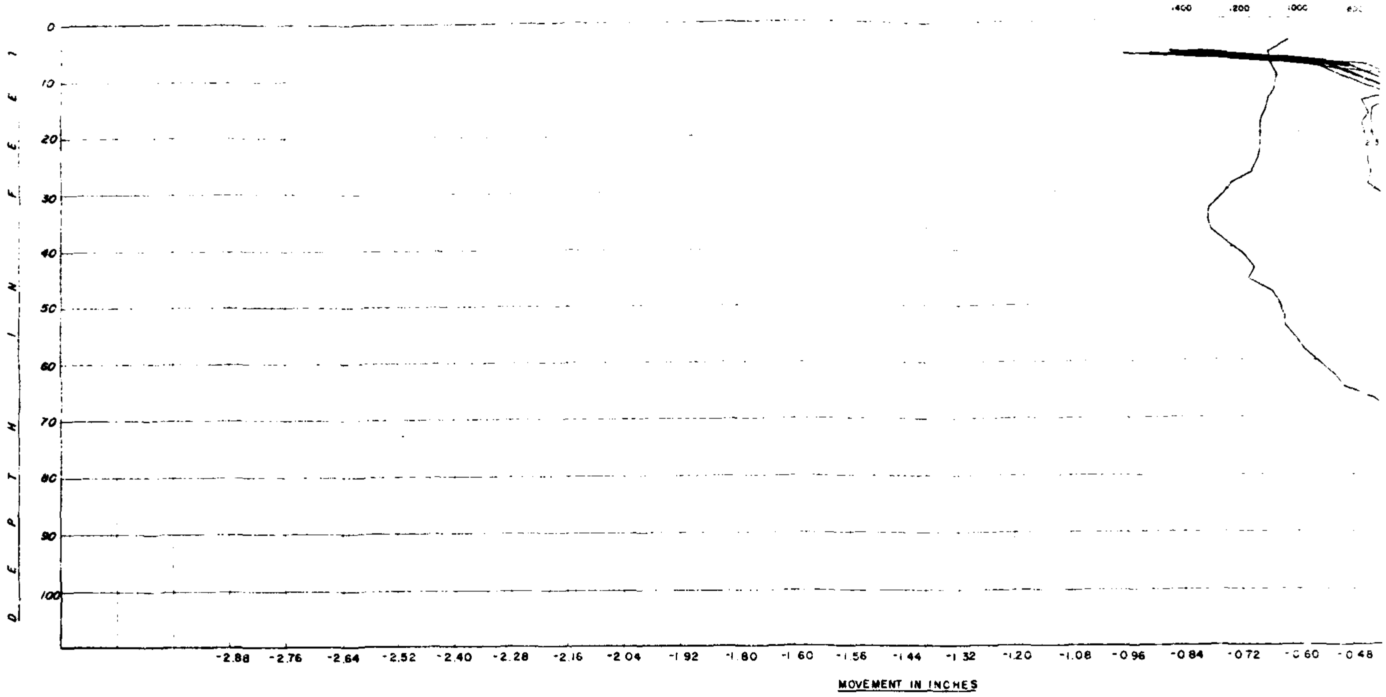
EMBANKMENT CRITERIA REPORT

INCLINOMETER
I-108-2

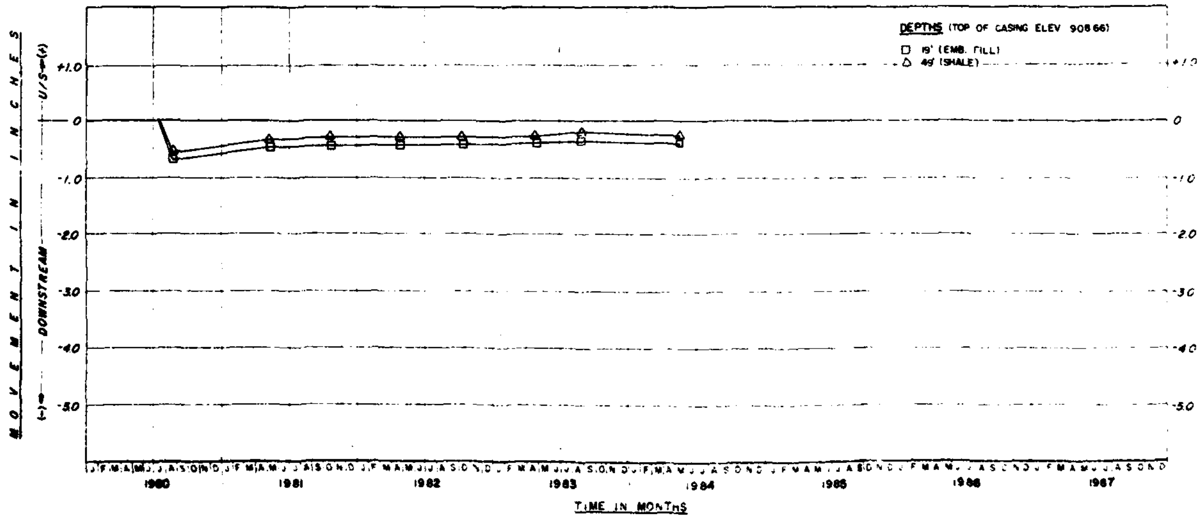
In 1 sheet — Sheet No. 1 — Scale: as shown

CORPS OF ENGINEERS U. S. ARMY
KANSAS CITY DISTRICT
FILE NO. O-15-1054
JANUARY 1984

2

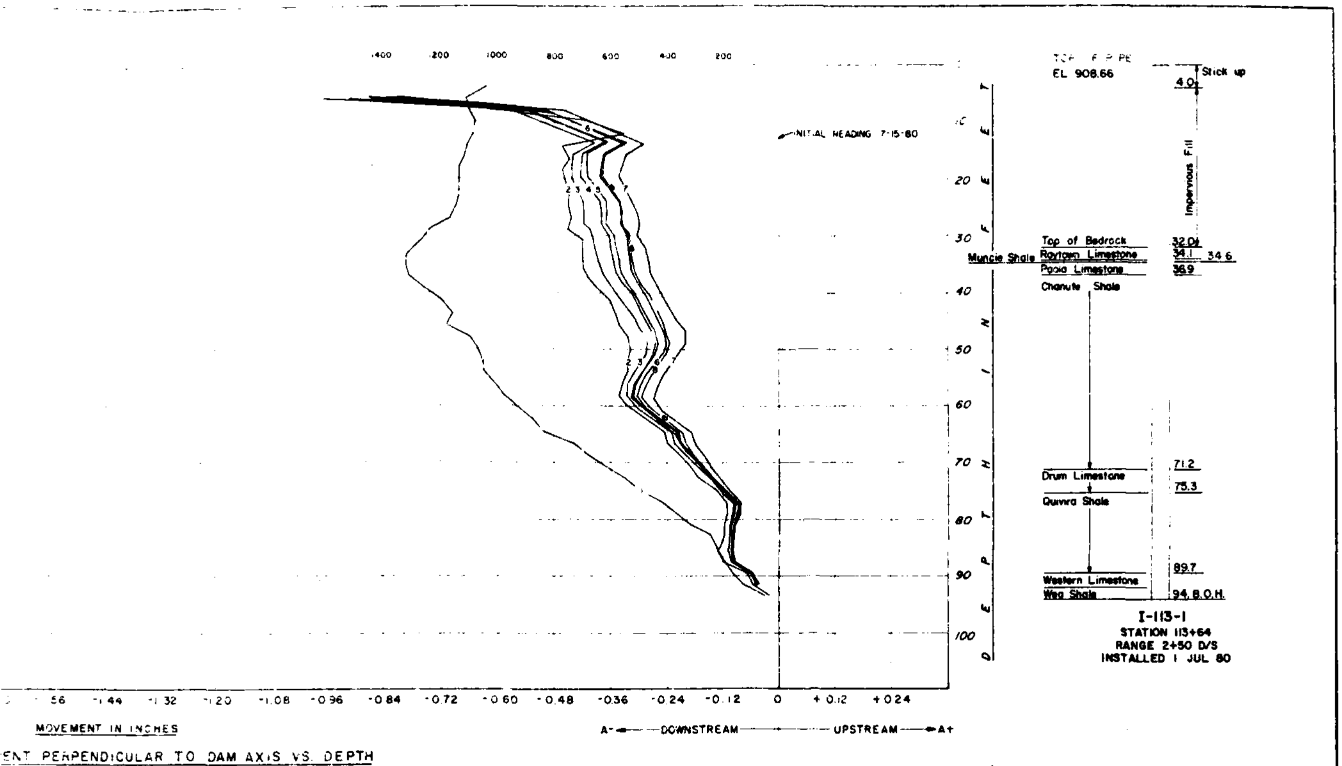


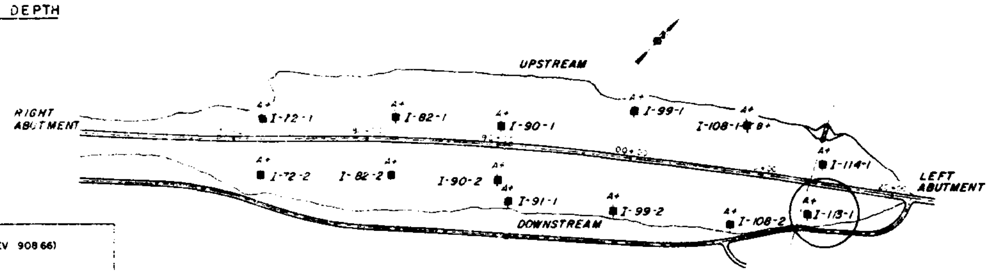
ACCUMULATED MOVEMENT PERPENDICULAR TO DAM AXIS VS. DEPTH

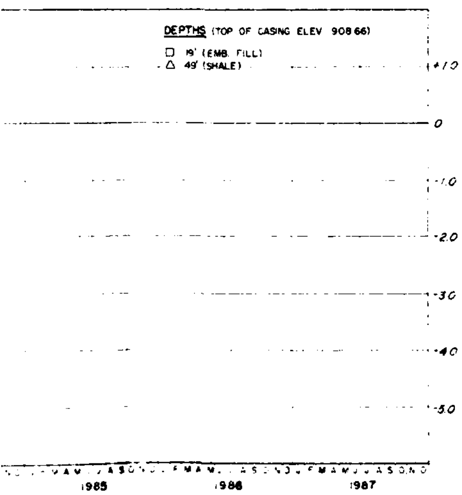


MOVEMENT VS TIME

(-) INDICATES DOWNSTREAM MOVEMENT







LEGEND

- —— 15 JUL 80 (INITIAL READING)
- —1— 18 AUG 80
- —2— 12 MAY 81
- —3— 20 OCT 81 (FIRST READING WITH DIGITILT)
- —4— 20 APR 82
- —5— 13 OCT 82
- —6— 27 APR 83
- —7— 22 SEP 83
- —8— 15 MAY 84

REVISED SEPTEMBER 1984
BIG BULL CREEK, KANSAS

HILLSDALE LAKE

EMBANKMENT CRITERIA REPORT

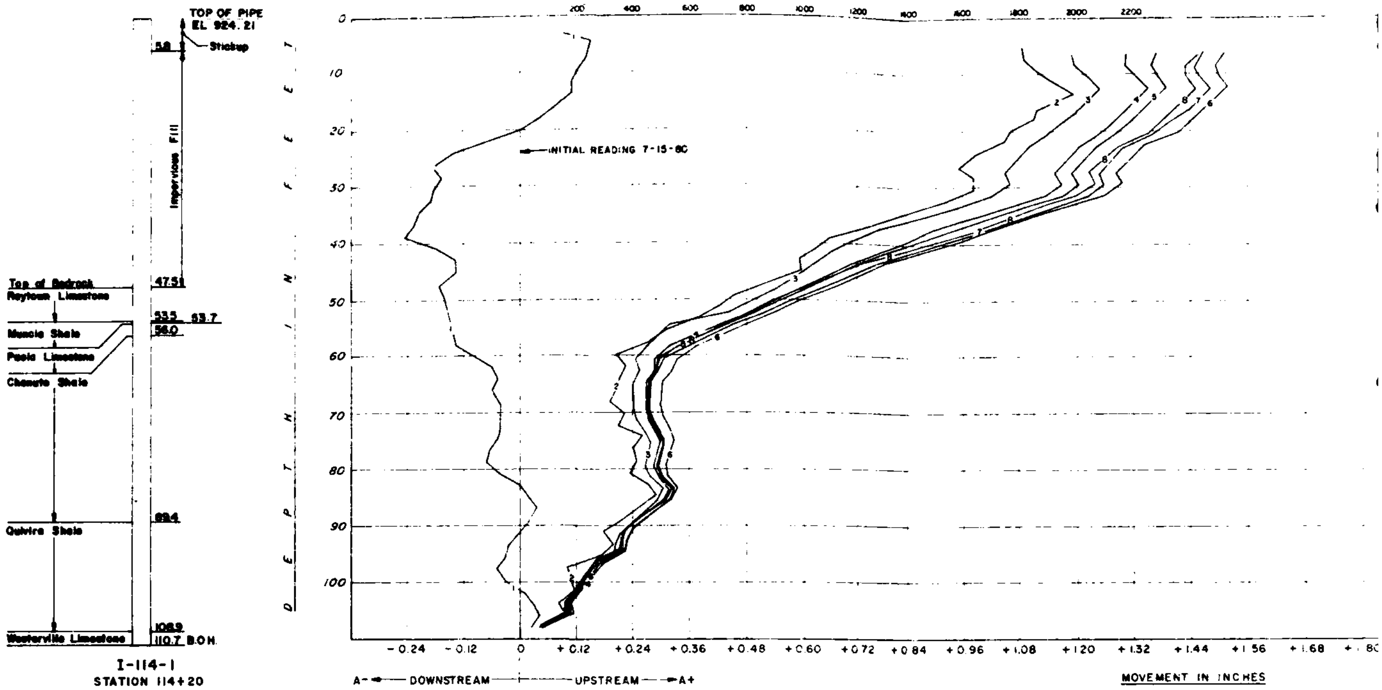
INCLINOMETER
I-113-1

In 1 sheet | Sheet No. 1 | Scale: as shown

CORPS OF ENGINEERS U. S. ARMY
KANSAS CITY DISTRICT
FILE NO. O-15-1065
JANUARY 1984

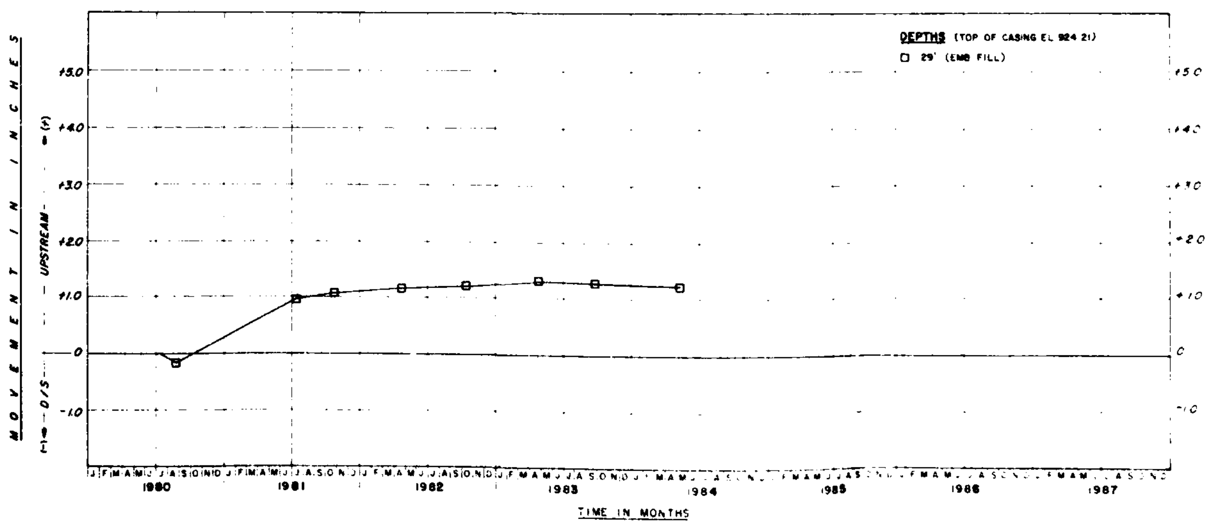
2

PLATE NO 270



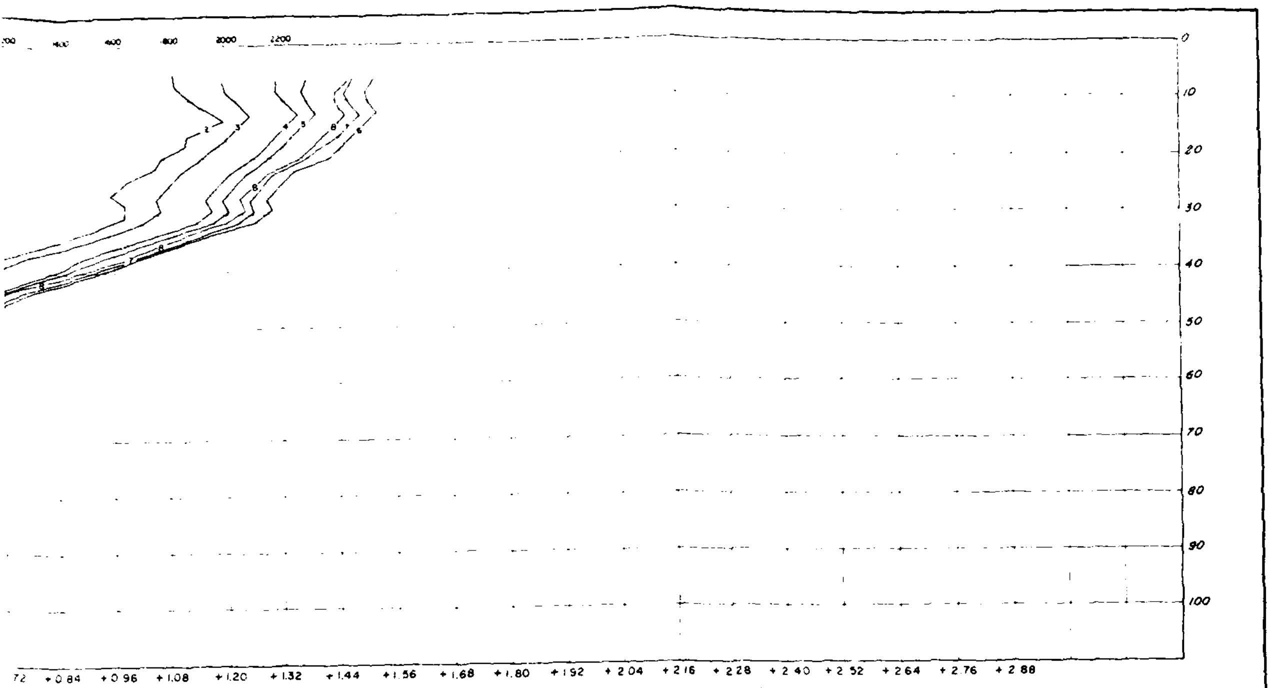
I-114-1
STATION 114+20
RANGE 1+40 U/S
INSTALLED 25 JUN 80

ACCUMULATED MOVEMENT PERPENDICULAR TO DAM AXIS

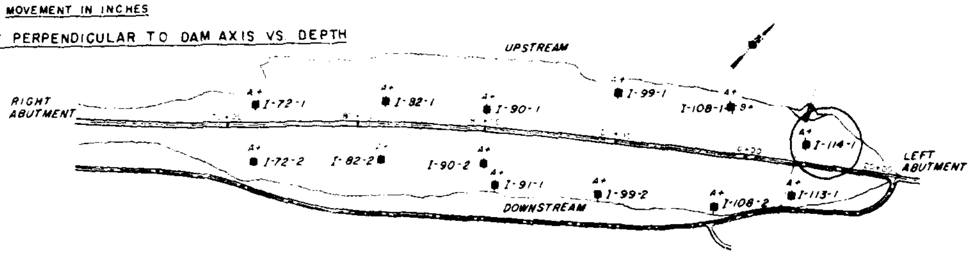


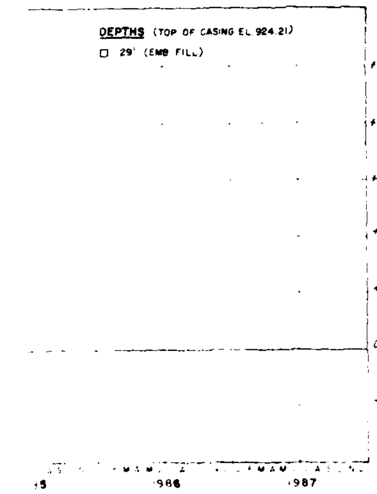
MOVEMENT VS TIME

(-) INDICATES DOWNSTREAM MOVEMENT



ACCUMULATED MOVEMENT PERPENDICULAR TO DAM AXIS VS DEPTH





LEGEND

- —— 15 JUL 80 (INITIAL READING)
- —1— 18 AUG 80
- —2— 8 JUL 81
- —3— 22 OCT 81 (FIRST READING W/ DIGITILT)
- —4— 20 APR 82
- —5— 14 OCT 82
- —6— 25 APR 83
- —7— 27 SEP 83
- —8— 15 MAY 84

REVISED SEPTEMBER 1984

BIG BULL CREEK, KANSAS

HILLSDALE LAKE

EMBANKMENT CRITERIA REPORT

INCLINOMETER
I-114-1

In 1 sheet | Sheet No 1 | Scale: as shown

CORPS OF ENGINEERS U S ARMY
KANSAS CITY DISTRICT

FILE NO. 0-15-1056

JANUARY 1984

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PLATE NO 271

END

DATE
FILMED

8 - 86